CHAPTER 6

POLLUTION PREVENTION, RECYCLING, TREATMENT, AND DISPOSAL TECHNOLOGIES EMPLOYED BY THE INDUSTRIAL LAUNDRIES INDUSTRY

6.1 Introduction

The Pollution Prevention Act of 1990 and EPA's 1991 Pollution Prevention Strategy established an environmental management hierarchy that includes (in order of highest priority) pollution prevention, recycling, treatment, and disposal or release. Presented in this chapter are the pollution control technologies applicable to the industrial laundries industry for each step of the environmental management hierarchy. This chapter presents the following discussions:

- Section 6.2 discusses the environmental management hierarchy established by the Pollution Prevention Act;
- Section 6.3 discusses the pollution prevention measures used in the industrial laundries industry;
- Section 6.4 discusses the waste recycling measures used in the industrial laundries industry;
- Section 6.5 discusses the major wastewater treatment technologies used by the industry;
- Section 6.6 discusses the waste disposal measures used by the industrial laundries industry; and
- Section 6.7 presents the references used.

At the time of proposal, EPA considered 193 facilities that responded to the 1994 Industrial Laundries Industry Questionnaire (detailed questionnaire) to be in scope, including three facilities that process only clean room items. After proposal, EPA determined that clean room items should not be classified as industrial laundry items (see Section 4.8 of this document) and the three clean room facilities are no longer considered to be in scope. Information in this chapter on the pollution prevention, recycling, wastewater treatment, and disposal practices reported by the industry are presented on the basis of 190 in-scope facilities.

6.2 The Environmental Management Hierarchy

As it applies to industry, the environmental management hierarchy (outlined in Figure 6-1) stipulates that:

I. Source Reduction

   A. Product Changes
      1. Design for Less Environmental Impact
      2. Increased Product Life

   B. Process Changes

      1. Input Material Changes
         - Material Purification
         - Substitution of Less Toxic Materials

      2. Technology Changes
         - Layout Changes
         - Increased Automation
         - Improved Operating Conditions
         - Improved Equipment
         - New Technology

      3. Improved Operating Practices
         - Operating and Maintenance Procedures
         - Management Practices
         - Stream Segregation
         - Material Handling Improvements
         - Production Scheduling
         - Inventory Control
         - Training
         - Waste Segregation

II. Recycling

   A. Reuse

   B. Reclamation

III. Treatment

Reference: United State EPA, Office of Research and Development. Facility Pollution Prevention Guide, EPA/600/R-92/088, May 1992.

Figure 6-1. Environmental Management Options Hierarchy

Facilities should reduce pollution at the source whenever feasible;

- Facilities should recycle waste materials that cannot be reduced in an environmentally safe manner whenever feasible;

- Facilities should treat pollution that cannot be reduced or recycled in an environmentally safe manner whenever feasible; and

- Facilities should only dispose or release pollutants into the environment as a last resort. Facilities should conduct this practice in an environmentally safe manner.

EPA examined pollution prevention, recycling, treatment and disposal practices applicable to the industrial laundries industry in an effort to incorporate the environmental management hierarchy into the industrial laundries regulatory options development process. As part of the Industrial Pollution Prevention Project (IP3) (1), a joint effort of EPA, state agencies, local agencies, and industrial laundries, EPA determined that industrial laundries can best identify pollution prevention and recycling opportunities by identifying all sources of pollution at their facilities, including hazardous wastes, solid wastes, air emissions, and water discharges. Then facility personnel and their customers can work together to find solutions which reduce or eliminate the generation of the wastes through source reduction, reuse, and recycling. Specific waste reduction opportunities at industrial laundries identified by EPA during the IP3 are presented in Sections 6.3 and 6.4 of this document. The information EPA collected on pollution prevention, recycling, treatment and disposal practices as part of the industrial laundries regulatory development process and the IP3 is presented in Sections 6.3 through 6.6 of this document.

6.3 Pollution Prevention/Source Reduction in the Industrial Laundries Industry

Pollution prevention, established as the most desirable pollution control option in the environmental management hierarchy, is defined as the use of materials, processes, or practices that reduce or eliminate the generation of pollutants or wastes at the source. Also known as source reduction, pollution prevention includes practices that reduce the use of hazardous and nonhazardous materials, energy, water, or other natural resources. End-of-pipe pollution control and waste-handling measures (including waste treatment, off-site recycling, volume reduction (e.g., sludge dewatering), dilution, and transfer of constituents to another environmental medium) are not considered pollution prevention because such measures are applied only after wastes are generated. With the Pollution Prevention Act of 1990, Congress established pollution prevention as a national goal, declaring that the generation of pollutants should be prevented or reduced during the production cycle whenever feasible.

In the detailed questionnaire, EPA asked industrial laundries to provide information on the types of pollution prevention activities performed at their facilities during the 1993 operating year. Of the 190 in-scope industrial laundries and three clean room item laundries responding to the detailed questionnaire (in-scope facilities are those that meet the definition of an industrial laundry as presented in Chapter 4 of this document), 44 industrial laundries reported having a pollution prevention policy (42 of these facilities attached copies of the plans to the questionnaire), and 53 industrial laundries stated that they planned to implement additional pollution prevention activities in the near future.

A total of 105 in-scope industrial laundries reported conducting pollution prevention activities prior to the laundering process (preprocess activities), during the laundering process (in-process activities), or both. The information reported by the facilities for preprocess and in-process pollution prevention activities is presented in Sections 6.3.1 and 6.3.2 of this document.

6.3.1 Preprocess Pollution Prevention Activities

Seventy-nine in-scope industrial laundries responding to the detailed questionnaire reported conducting some type of preprocess pollution prevention activities during the 1993 operating year. Table 6-1 presents the number of industrial laundries, by production category, that reported preprocess pollution prevention activities. EPA analyzed the data in the questionnaire responses to determine if facility size was a factor in the performance of preprocess pollution prevention activities. For each production category, EPA calculated the percentage of industrial laundries that reported these activities by dividing the number of industrial laundries reporting activities by the total number of industrial laundries listed in that production category. As shown in Table 6-1, the performance of preprocess pollution prevention activities does not appear to be related to facility size, with approximately 30 to 50 percent of the facilities in each production category reporting preprocess pollution prevention activities.

Table 6-2 lists all of the preprocess pollution prevention activities reported by industrial laundries in the detailed questionnaire. The most common preprocess pollution prevention activities reported were the refusal of items with free liquids (68 percent) and the refusal of certain items (52 percent). The items most often refused by the industrial laundries were shop and printer towels/rags. Sixteen industrial laundries reported other preprocess activities, including centrifugation of items to remove liquids, dry cleaning of items before water washing, presorting of items to remove trash/objects, and steam/air stripping of volatiles from items. During the IP3, EPA identified preprocess pollution prevention practices that could be implemented by industrial laundries. In addition to the preprocess pollution prevention activities already presented in this section, EPA determined that industrial laundries could reduce the amount of solid waste generated at their facilities by having laundering/dry cleaning/wastewater treatment chemicals shipped to the facilities in bulk containers or in drums that could be returned to the chemical manufacturers.

Centrifugation, steam/air stripping, and dry cleaning are used to remove liquid solvents and volatile organic compounds (VOCs) from items prior to water washing. These technologies facilitate the recovery and recycle of solvents and other materials contained on heavily soiled items, such as shop and printer towels/rags. Although these technologies are

Table 6-1

Number of Industrial Laundries, by Production Category, Reporting Preprocess Pollution Prevention Activities in the Detailed Questionnaire for the 1993 Operating Year

Production Category (lb/yr)	Number of Facilities Reporting Activities	Total Number of Facilities in Production Category	Percentage of Facilities Reporting Activities in Production Category	Total Production for Facilities Reporting Activities (lb/yr)	Percentage of Total Production for Facilities Reporting Activities
< 1,000,000	9	19	47%	5,810,000	1%
1,000,000 to < 3,000,000	14	37	38%	27,900,000	6%
3,000,000 to < 6,000,000	23	58	40%	102,000,000	21%
6,000,000 to < 9,000,000	17	33	52%	123,000,000	25%
9,000,000 to < 15,000,000	10	25	40%	115,000,000	23%
≥ 15,000,000	6	18	33%	118,000,000	24%
Total	79	190	---	492,000,000	100%

Table 6-2

Types of Preprocess Pollution Prevention Activities Reported in the Detailed Questionnaire for the 1993 Operating Year

Activity	Number of Facilities Performing Activity	Percentage of Total Number of Facilities Reporting Preprocess Activities[1]
Refusal of Items with Free Liquids	54	28%
Refusal of Certain Items	41	22%
Centrifugation of Items to Remove Liquids	6[2]	3%
Items Dry-Cleaned Before Water Washing	5[3]	3%
Items Presorted to Remove Objects	3	2%
Steam/Air Stripping of Volatile Organics from Items	1[4]	1%

[1]Percentages are based on 190 in-scope industrial laundries.
[2]Some of these facilities reported that their customers were “pressing,” “squeezing,” “extracting,” or “centrifuging” the items prior to sending them to the laundry.
[3]Three of these facilities did not report dry cleaning before water washing as a preprocess pollution prevention activity. This information was obtained from their reported laundering processes. One additional facility dry cleans items before water washing, but the industrial laundry did not include this information in its detailed questionnaire. EPA obtained this information during a site visit to the facility.
[4]One additional facility reported steam/air stripping of volatile organics from items; however, the particular activities reported at this facility do not meet the definition of steam/air stripping.

actually waste recycling techniques with treatment, they were presented in the detailed questionnaire as preprocess pollution prevention techniques. For this reason, the information provided by the industry on these technologies in the detailed questionnaire are included in this section. Centrifugation, steam/air stripping, dry cleaning, and other waste recycling/treatment technologies are discussed in greater detail in Section 6.4 of this document.

Facilities responding to the detailed questionnaire reported initiating preprocess pollution prevention activities primarily in the late 1980s and early 1990s. However, several facilities initiated refusal of certain items and the refusal of items with free liquids many years before (the late 1950s and early 1980s, respectively). Facilities that reported these two practices tended to refuse the same items, as shown in the following table:

Items refused	Percentage of Facilities Refusing Items	
	Facilities Refusing Items with Free Liquids	Facilities Refusing Certain Items
Shop towels	48%	27%
Printer towels/rags	28%	32%
Industrial garments	15%	12%

Of the six facilities that reported centrifugation to remove liquids, four performed this activity on shop or printer towels/rags (the centrifugation technology is discussed in greater detail in Section 6.4.5 of this document). Likewise, both of the facilities that reported steam/air stripping of volatile organics from items performed this activity on shop or printer towels/rags. None of the facilities that presorted items to remove trash/objects or dry cleaned items before water washing reported performing these activities on shop or printer towels/rags.

In the detailed questionnaire, EPA asked facilities to report whether performing preprocess pollution prevention activities had a negative impact on the quality of their service. The facilities reported a negative impact most frequently for steam/air stripping of volatile organics from items (100 percent), the refusal of items with free liquids (65 percent), and the refusal of certain items (54 percent). These negative impacts generally included the following:

- Increased burden and costs for the facility (e.g., training of customers, installation of equipment);
- Increased burden and costs for the customers (e.g., purchase of equipment, restricted use of certain items, payment of penalty fees);
- Delayed service; and
- Loss of business/limits to growth.

EPA collected analytical data on two preprocess pollution prevention technologies, dry cleaning prior to water washing and steam stripping (steam tumbling), during site visit and sampling activities. EPA collected additional information on air stripping, centrifugation, and hydraulic pressing from vendors of the equipment. Section 6.4 of this document discusses these technologies and their application in the industry in more detail.

6.3.2 In-Process Pollution Prevention Activities

Fifty industrial laundries reported conducting some type of in-process pollution prevention activities during the 1993 operating year. Table 6-3 presents the number of industrial laundry facilities, by production category, that reported in-process pollution prevention activities. EPA analyzed the data in the questionnaire database to determine if facility size was a factor in the performance of in-process pollution prevention activities. For each production category, EPA calculated the percentage of facilities that reported activities by dividing the number of facilities reporting activities by the total number of facilities listed in that production category. As shown in Table 6-3, the performance of in-process pollution prevention activities does not appear to be related to facility size, with 15 to 35 percent of the facilities in each production category reporting in-process pollution prevention activities.

Table 6-4 lists all in-process pollution prevention activities reported by industrial laundries in the detailed questionnaire for the 1993 operating year. The most common types of in-process pollution prevention activities reported by the industrial laundries were:

- A change in the use of laundering/dry-cleaning chemicals (11 percent);
- Improved training of employees (i.e., chemical safety, proper handling of equipment) (10 percent); and
- Installation of a liquid injection system to add the exact amount of wash chemicals required by the wash formula (10 percent).

A smaller number of facilities reported other in-process activities (improved housekeeping, water softening, implementation of water reuse/reduction, equipment modifications/installations, recycling of laundry materials, removal of lint before air venting to atmosphere, and reduced fuel consumption). During the IP3, EPA identified in-process pollution practices that could be implemented by industrial laundries. In addition to the in-process pollution prevention activities already presented in this section, EPA determined that industrial laundries could also technically implement the following in-process practices:

- Use calcium extracted from incoming water during water softening to replace the lime used in wastewater treatment/sludge dewatering operations;
- Separate nonhazardous and hazardous waste streams;
- Improve standard operating procedures;
- Establish an inventory control system;

Table 6-3

Number of Industrial Laundries, by Production Category, Reporting In-Process Pollution Prevention Activities in the Detailed Questionnaire for the 1993 Operating Year

Production Category (lb/yr)	Number of Facilities Reporting Activities	Total Number of Facilities in Production Category	Percentage of Facilities Reporting Activities in Production Category	Total Production for this Category for Facilities Reporting Activities (lb/yr)	Percentage of Total Production for Facilities Reporting Activities
< 1,000,000	5	19	26%	3,280,000	1%
1,000,000 to < 3,000,000	13	37	35%	23,000,000	7%
3,000,000 to < 6,000,000	14	58	24%	62,300,000	20%
6,000,000 to < 9,000,000	10	33	30%	76,700,000	25%
9,000,000 to < 15,000,000	4	25	16%	51,100,000	17%
≥ 15,000,000	4	18	22%	93,100,000	30%
Total	50	190	---	309,000,000	100%

Table 6-4

Types of In-Process Pollution Prevention Activities Reported in the Detailed Questionnaire for the 1993 Operating Year

Activity	Number of Facilities Performing Activity	Percentage of Total Number of Facilities Reporting In-Process Activities[1]
Change in Laundering/Dry Cleaning Chemicals Used	20	11%
Improved Training of Employees	19	10%
Liquid Injection System for Wash Chemical Addition	18	10%
Improved Housekeeping	10	5%
Water Softening	6	3%
Equipment Modifications/Installations	3	2%
Recycling of Laundry Materials	1	1%
Removal of Lint Before Air Venting to Atmosphere	1	1%
Reduced Fuel Consumption	1	1%

[1]Percentages are based on 190 industrial laundries.

- Perform routine and preventative maintenance on facility equipment;
- Utilize waste exchange programs; and
- Reuse solvent from dry-cleaning operations.

Facilities responding to the detailed questionnaire reported initiating most in-process pollution prevention activities primarily in the late 1980s and early 1990s. However, one facility reported initiating improved training of employees in 1983.

All of the in-process pollution prevention activities reported by the facilities reduce pollution and reduce operating costs by optimizing facility operations. The installation of alternative washers and automated liquid injection systems for washers, the use of alternative washing chemicals, the use of water softening, and the implementation of water reuse/reduction all can reduce the amount of water and/or chemicals that a facility uses. A significant number of facilities have improved employee training and housekeeping standards; these activities can also decrease water and chemical use. In addition, changes in laundering chemicals were reported to improve treatability of the wastewater by forming emulsions that are more easily broken.

In the detailed questionnaire, EPA asked facilities to report whether performing pollution prevention activities had a negative impact on the quality of their service. While most of the industrial laundries reported no negative impacts for the in-process activities, several facilities did report a negative impact on their quality of service from in-process pollution prevention activities. These negative impacts generally included the following:

- Increased burden and costs for the facility (e.g., training of employees, purchase of more expensive liquid chemicals, installation of equipment/ processes, disposal of recovered materials);
- Increased costs to the customers (i.e., increased facility costs were passed on to customers); and
- Decreased quality of service (e.g., graying of clothes).

The in-process pollution prevention activities were more widely practiced on the different items laundered than were the preprocess pollution prevention activities. Since most of the in-process activities affect all washing operations, this wide distribution among all of the item types is to be expected. For example, in-process activities such as liquid injection usually apply to all laundry operations and item types at a facility.

6.4 Waste Recycling/Resource Conservation and the Industrial Laundries Regulatory Development Process

As established in the environmental management hierarchy, if the generation of waste materials cannot be prevented or reduced in an environmentally safe manner, these materials should be recycled whenever feasible. Waste recycling conducted in an environmentally safe manner shares many of the advantages of pollution prevention/source reduction. Waste recycling helps to conserve natural resources, such as energy and water. In addition, pollution recycling reduces the need for end-of-pipe treatment or disposal, the two least desirable pollution control measures in the environmental management hierarchy.

During the IP3, EPA determined that most industrial laundries use heat exchangers to conserve energy. But, EPA determined that many industrial laundries do not recycle any process water. As part of the industrial laundries regulatory development process, EPA asked industrial laundries receiving the detailed questionnaire and the 1993 Screener Questionnaire for the Industrial Laundries Industry to provide information on the types of pollution recycling/resource conservation activities performed at their facilities. The information reported by the facilities for water reuse and energy reuse is summarized in Sections 6.4.1 and 6.4.2 of this document. Also included in this section is information pertaining to technologies used to remove liquid solvents and VOCs from items prior to water washing (Sections 6.4.3 through 6.4.6). These technologies facilitate the recovery and recycle of solvents and other materials contained on heavily soiled items, such as shop and printer towels/rags. The recovered materials may then be reused by the industrial laundry customers or blended into fuel.

6.4.1 Water Conservation in the Industrial Laundries Industry

Industrial laundries have a variety of opportunities to recycle/reuse water at their facilities. Industrial laundries can recycle or reuse the following sources of water used at the facility as process water or cooling water: laundry wastewater before treatment, laundry wastewater after treatment, noncontact cooling water, contact cooling water, and nonlaundry wastewater.

Forty-five of the 190 in-scope industrial laundries (24 percent) responding to the detailed questionnaire reported reusing a portion of the water used by the facility as process makeup water. Twenty-seven industrial laundries (60 percent) reported reusing noncontact cooling water as process makeup water. Nineteen facilities (42 percent) reported reusing laundry wastewater in the water-washing process before the wastewater had been treated. One of the industrial laundries reported reusing the final rinse from the water-washing process as noncontact cooling water. The noncontact cooling water was then reused at the first rinse in the water-washing process. Eight facilities (18 percent) reported recycling/reusing laundry wastewater back into the water-washing process after the wastewater had been treated. One facility (2 percent) reported reusing nonlaundry wastewater as laundry process water. This facility did not specify the source of the nonlaundry wastewater. No facilities responding to the detailed questionnaire reported reusing contact cooling water.

6.4.2 Energy Conservation in the Industrial Laundries Industry

EPA asked facilities to indicate in the screener questionnaire whether they conserve energy by operating a heat reclaimer. Heat reclaimers at industrial laundries typically operate by transferring heat from the process waste stream to preheat incoming service water. The service water that has been preheated is then used in the wash process. Six hundred sixty-three of the 1,500 facilities responding to the screener questionnaire (44 percent) reported operating a heat reclaimer at their facility.

6.4.3 Dry Cleaning of Solvent Laden Items Prior to Water Washing

General Description

Dry cleaning effectively removes volatile organic compounds (VOCs) from laundry items prior to water washing, thereby reducing the introduction of VOCs into industrial laundry wastewater. Dry cleaning involves cleaning soiled items with an organic-based solvent that removes VOCs as well as heavy organic pollutants (e.g., oil and grease). The pollutants usually are separated from the solvent through distillation and are then disposed. The distilled solvent may then be reused in subsequent dry cleaning processes. Depending on the purity of the pollutants removed from the cleaning solvent, there may be a potential for recycling these for reuse by the customer or for fuel blending.

Industry Application

Five of the 190 in-scope industrial laundries responding to the detailed questionnaire (three percent) reported dry cleaning items before water washing. Four of these facilities reported that they dispose of residual solvent as hazardous waste (one facility did not include this information in its detailed questionnaire response). Three of the four facilities reported that they were large-quantity generators (disposing of greater than 1,000 kilograms of waste per month) and the other facility reported that it was a small-quantity generator (disposing of between 100 and 1,000 kilograms of waste per month).

One of the facilities reuses a significant portion of its cleaning solvent by reusing the solvent from the final rinse from one load as the initial rinse in a subsequent load. In addition, the facility reclaims much of the used solvent by fractionating it in an on-site distillation column. The facility collects the mid-range fractions for reuse and disposes of the light and heavy ends to a hazardous waste incinerator (2).

6.4.4 Steam/Air Tumbling of Solvent Laden Items Prior to Water Washing

General Description

Steam or air tumbling is used to remove VOCs from laundry items prior to water washing to reduce the amount of VOCs introduced into the laundry wastewater. In steam tumbling, soiled items are agitated within a modified washer/extractor while steam is injected into the extractor chamber. The heat from the steam causes the VOCs to evaporate from the surfaces of the items. The steam and volatilized VOCs are then removed from the tumbler chamber. The steam and volatilized VOCs are sent to a condensing unit where the steam is condensed and the VOCs are recovered through a phase separation. Air tumbling works similarly to steam tumbling, except hot air is used as the source of heat to evaporate the VOCs and phase separation is not required. The VOCs are simply condensed out of the hot air stream. Depending on the purity of the VOC (solvent) recovered from the steam or air tumbling operation, it may be reused by the customer or sent away for fuel blending.

One equipment manufacturer estimates that 90 to 95 percent of the VOC solvent is recovered using its equipment and claims that some customers have achieved a removal efficiency of 98 percent (3). EPA also collected samples of wastewater discharged after processing a load of printer towels/rags that was steam-tumbled prior to water washing and from a load that was not steam-tumbled prior to water washing.

EPA used these samples to identify pollutants removed by steam tumbling by comparing the pollutant concentrations in the washer wastewater from non-steam-tumbled towels/rags to that of towels/rags that were steam tumbled prior to washing to demonstrate changes in the untreated wastewater characteristics from steam tumbling. The data are presented in Table 6-5. All volatile organic pollutants for which a removal could be calculated (pollutant removals for seven volatile organics could not be calculated because the pollutant was not detected in the influent) had greater than 90 percent removal. Therefore, EPA considered organic pollutants with greater than 90 percent removal to be removed by steam tumbling. Based on this criterion, EPA considered all volatile organic pollutants (14 of the 72 pollutants of concern) to be removed by steam tumbling. Ten semivolatile organic pollutants from the list of 72 pollutants of concern for which a removal could be calculated (pollutant removals for eight semivolatile organic pollutants could not be calculated because the pollutant was not detected in the influent) also had greater than 90 percent removal. EPA considered these 10 semivolatile organic pollutants to be removed by steam tumbling. A more detailed discussion of the steam tumbler treatment performance data can be found in Chapter 9 of the Technical Development Document for the proposal rule (4).

However, this data are limited in its usefulness because it is not a direct comparison of the pollutants contained on the printer towels/rags before and after processing them in the steam tumbler. In addition, the results of this comparison show that although steam tumbling removes volatile and semivolatile pollutants, it does not effectively remove nonvolatile pollutants, as evidenced by only 10 percent removal of total petroleum hydrocarbon (measured by SGT-HEM)[1].

[1]Silica gel treated-hexane extractable material (SGT-HEM) is measured by Method 1664 (promulgated at 64 FR 26315; May 14, 1999). In this method, EPA defines SGT-HEM as non-polar material (NPM). Throughout this document and the Industrial Laundries Administrative Record, EPA refers to SGT-HEM as total petroleum hydrocarbon (TPH).

Table 6-5

Steam Stripping Performance Data Collected from a Sampled Facility Processing Printer Towels in a Steam Tumbler Prior to Water Washing

Pollutant of Concern	Printer Towel/Rag Raw Wastewater Concentration (mg/L)	Steam Tumbled Printer Towel/Rag Raw Wastewater Concentration (mg/L)	Percent Removal
Bulk Nonconventionals			
Total Petroleum Hydrocarbon (measured as SGT-HEM[1])	519	468	10%
Total Organic Carbon	2480	1770	29%
Priority Organics			
1,1,1-Trichloroethane	4.24	0.0118	100%
Butyl Benzyl Phthalate	6.30	0.366	94%
Chlorobenzene	< 0.1	< 0.01	90%
Chloroform	< 0.1	< 0.01	90%
Ethylbenzene	9.78	< 0.01	100%
Methylene Chloride	0.161	< 0.01	94%
Naphthalene	3.73	0.226	94%
Tetrachloroethene	3.21	< 0.01	100%
Toluene	14.2	0.0436	100%
trans-1,2-Dichloroethene	< 0.1	< 0.01	90%
Trichloroethene	< 0.1	< 0.01	90%
Nonconventional Organics			
2-Butanone	2.24	< 0.05	98%
2-Methylnaphthalene	0.699	< 0.04	94%
2-Propanone	23.4	0.681	97%
4-Methyl-2-pentanone	< 0.5	< 0.05	90%
∝-Terpineol	1.58	< 0.04	97%
m-Xylene	< 0.1	0.0151	85%
n-Decane	158	0.499	100%
n-Dodecane	41.8	2.65	94%
n-Hexacosane	1.30	0.0904	93%
n-Octacosane	1.01	0.0633	94%

Table 6-5 (Continued)

Pollutant of Concern	Printer Towel/Rag Raw Wastewater Concentration (mg/L)	Steam Tumbled Printer Towel/Rag Raw Wastewater Concentration (mg/L)	Percent Removal
Nonconventional Organics (Continued)			
n-Triacontane	0.777	0.0587	92%
o-&*p*-Xylene	< 0.1	0.0146	85%
p-Cymene	19.8	< 0.04	100%

[1]Silica gel treated-hexane extractable material (SGT-HEM) is measured by Method 1664 (promulgated at 64 FR 26315; May 14, 1999). In this method, EPA defines SGT-HEM as non-polar material (NPM). Throughout this document and the Industrial Laundries Administrative Record, EPA refers to SGT-HEM as total petroleum hydrocarbon (TPH).

Industry Application

One of the 190 in-scope industrial laundries responding to the detailed questionnaire reported steam tumbling printer towels/rags before water-washing. This facility reported that it was a large-quantity hazardous waste generator (disposing of greater than 1,000 kilograms of waste per month) and that the hazardous waste residuals collected from the steam tumbler were disposed to fuel blending. Another facility (as noted in Table 6-2) reported "airing out" wet items prior to water washing, however, EPA does not consider this to be acceptable air stripping technology because the VOCs removed from the items are not collected.

EPA sampled the facility that steam-tumbled its printer towels/rags. Table 6-5 compares the pollutant concentrations in the washer wastewater (i.e., raw wastewater) from non-steam-tumbled towels to that of towels that were steam tumbled prior to washing.

6.4.5 Centrifuging of Solvent Laden Items Prior to Water Washing

General Description

Centrifugation is used to remove VOCs from laundry items before water washing. In centrifugation, items to be laundered are placed in a mesh bag or perforated basket. The bag or basket is placed in a centrifuge chamber, which is designed to spin around a central axis. The centrifugal forces generated by the spinning chamber act on both the laundry items and the solvent in the items. The bag or basket retains the laundry items while the solvent is forced through the mesh or perforations. The recovered solvent may be reused or recycled, depending on its purity.

In a test performed by EPA on an industrial centrifuge, the solvent removal efficiency ranged from 88 to 99 percent (5). Variables that affected removal efficiency during the test were the vapor pressure and boiling point of the solvent, the type of towel or wiper, and the presence of ink, water, dirt, oil, and other contaminants in the solvent. Additionally, vendor literature indicates 85 to 95 percent removal efficiency for centrifugation (6).

In a case study conducted by EPA, a printing facility centrifuged its towels before they were sent to the laundry, between 2.5 and 3.5 gallons of solvent were recovered for every 220 wipers (7). The facility used the recovered solvent to clean press ink trays. Solvent recovered from the cleaning operation was sent to a fuel blender.

Industry Application

None of the industrial laundries responding to the detailed questionnaire reported using centrifugation to remove VOCs from laundry items prior to water washing and the extent of its use in the industrial laundry industry is not known at this time. However, available information indicates that centrifugation is used in the printing industry to remove solvents from printer towels/rags before they are sent to a laundry (8). As noted in Table 6-2, there are six industrial laundries that reported washing centrifuged items (these items were sometimes reported as “extracted,” “pressed,” or “squeezed”). Most of these facilities reported that this activity was performed by their customers.

6.4.6 Pressing Solvent Laden Items Prior to Water Washing

General Description

Another way in which industrial laundries can remove excess liquid solvent and VOCs from items prior to water washing is by using a hydraulic ram extractor. Solvent laden items are placed into a perforated chamber. The items are then squeezed by a hydraulic ram that is actuated to compress the items within the chamber. The excess liquid solvents contained on the items flow through the perforations and into a collection system. As described previously, the recovered solvents may be processed for reuse or disposed by the laundry.

Industry Application

EPA knows of two facilities that use hydraulic presses to remove excess liquids from towels and adsorbents prior to water washing. One facility, sampled by EPA, disposes of the collected liquids with other waste oil collected from its wastewater treatment system to a hazardous waste fuel blender (9). The other facility, visited by EPA, also sends its extracted material to a fuel blender. This facility estimates that 30 to 70 pounds (5.5 gallons on average) of material is extracted for each 350-pound load of towels (10).

6.5 Wastewater Treatment Technologies in the Industrial Laundries Industry

This section describes major wastewater treatment technologies used in the industrial laundries industry, based on responses to the detailed questionnaire. Sections 6.5.1 through 6.5.15 of this document describe the wastewater treatment technologies used in the industry, as reported in the detailed questionnaire. These treatment technologies include:

- Gravity settling (Section 6.5.1);
- Stream splitting (Section 6.5.2);
- Screening (Section 6.5.3);
- Equalization (Section 6.5.4);
- Chemical emulsion breaking (Section 6.5.5);
- Chemical precipitation (Section 6.5.6);
- Dissolved air flotation (DAF) (Section 6.5.7);
- Sludge dewatering (Section 6.5.8);
- pH adjustment (Section 6.5.9);
- Ultrafiltration (Section 6.5.10);
- Centrifugation (Section 6.5.11);
- Oil/water separation (Section 6.5.12);
- Media filtration (Section 6.5.13);
- Carbon adsorption (Section 6.5.14); and
- Air stripping (Section 6.5.15).

Each technology section includes a general description of how the technology works, the types of pollutants the technology treats, and the application of the technology in the industrial laundries industry as of 1993. Table 6-6 presents the total number of facilities out of 190 in-scope facilities responding to the detailed questionnaire that reported using each of these technologies. Section 6.5.16 of this document presents updated information on the wastewater treatment technologies currently used by the industrial laundries industry that was collected in 1998 by the industrial laundries trade associations.

6.5.1 Gravity Settling

General Description

Gravity settling, or sedimentation, is primarily used to remove suspended solids from industrial laundry process wastewater. The wastewater is typically collected in a catch basin where the water is detained for a period of time, allowing solids with a higher specific gravity to settle to the bottom of the tank and solids with a lower specific gravity to float to the surface. The effectiveness of solids settling depends upon the characteristics of the laundry wastewater and the length of time the wastewater is held in the catch basin. Properly designed and operated settling tanks are capable of achieving significant reductions of suspended solids and 5-day biochemical oxygen demand (BOD_5) (11).

The solids that settle out or float to the surface may be removed from the basin continuously using automated rakes or augers that scrape the solids into a collection unit for subsequent dewatering or disposal. Alternatively, the basins may be periodically shut down and the solids pumped out and collected for disposal.

Industry Application

It was assumed that a facility reporting a catch basin with an amount of solids removed had gravity settling. Although only 51 percent of in-scope industrial laundries responding to the detailed questionnaire (97 of 190) reported treating their wastewater through gravity settling, every facility visited by EPA has a settling basin in place. Therefore, EPA believes all industrial laundries have settling basins in place and can incorporate gravity settling and solids removal as part of their treatment train without modification of their wastewater treatment equipment. The gravity settling units used at these 97 facilities have an average residence time of 2.3 hours. Ten industrial laundries add chemicals to their gravity settling unit, most frequently sulfuric acid (added by six facilities) and polymer (added by two facilities).

6.5.2 Stream Splitting

General Description

Segregating process wastewater streams provides a means of treating a portion of the total process wastewater generated at industrial laundries. Stream splitting may be used to isolate and treat a stream with a high pollutant load, while a stream with a lower load is either

Table 6-6

Number of In-Scope Facilities Responding to Detailed Questionnaire Using Wastewater Treatment Technologies in the 1993 Operating Year

Technology	Number of Facilities Using Technology	Percentage of Total Number of Industrial Laundries Responding to the Detailed Questionnaire[1]
Gravity Settling	97	51%
Stream Splitting	20	11%
Screening	146	77%
Equalization	98	52%
Chemical Emulsion Breaking	9	5%
Chemical Precipitation	21	11%
Dissolved Air Flotation	35	18%
Sludge Dewatering	52	27%
pH Adjustment	42	22%
Ultrafiltration	2	1%
Centrifugation	6	3%
VOC Removal Technologies	12	6%
Oil/Water Separation	24	13%
Media Filtration	10	5%

[1]Percentages are based on the 190 in-scope industrial laundries that responded to the detailed questionnaire.

recycled and reused or discharged directly to the publicly owned treatment works (POTW) without treatment. This segregation allows a facility to install a smaller treatment system than would be necessary if the total process wastewater stream was treated. In addition, facilities can reduce overall process water use if they can reuse the less concentrated wastewater in place of a portion of fresh service water.

A divided trench and sump system is used to split process wastewater streams. This system is installed as two completely separate trenches and/or sumps, or an existing system may be modified to accommodate two separate wastewater streams. One modification to an existing system entails placing a dividing wall down the center of the existing trench and/or sump. This wall may be constructed of concrete, coated metal plates, or other impervious material. Alternatively, one stream may be hard piped to a specific treatment unit or collection tank while the other stream flows through the existing trench and sump. Pipe made of polyvinyl chloride (PVC) is generally used because of its compatibility with industrial laundry process wastewater pH and temperatures. Facilities often need to install additional collection tanks and transfer pumps to accommodate the two process wastewater streams (12).

In addition to splitting the facility's process wastewater trench and sump system, the washer, extractor, and/or washer-extractor machines must either be capable of releasing process wastewater into separate conduits or be used as dedicated machines for washing a specific item or group of items so the wastewater discharge can be directed to the appropriate trench. Machines can be purchased having multiple water discharge ports and control valves to allow each process break or rinse to be released to a separate location according to the wash formula. For example, the operator may program the washer/extractor to release the initial wash breaks containing the dirtier water to the treatment system to be treated and discharged, while routing the final rinses to a storage tank to be recycled in subsequent washing processes or to be discharged without treatment. Existing machines that do not currently have this capability can be retrofitted with control and discharge valves. Another method of segregating process wastewater is to identify items that generate the more polluted water and those that generate cleaner water. The facility may then designate certain machines to wash a specific group of items and direct all of the process wastewater from those machines to the desired location.

Industry Application

Eleven percent of in-scope industrial laundries responding to the detailed questionnaire (20 of 190) reported segregating their process wastewater streams to treat a portion of the total process wastewater generated at their facilities. One additional facility responding to the detailed questionnaire reported having the capability to segregate its process wastewater stream but did not report treating any portion of this process wastewater.

6.5.3 Screening

General Description

Wastewater is often screened prior to subsequent treatment to remove grit and suspended solids that may potentially damage or clog process equipment located downstream.

Coarse screening is often performed using a bar screen, constructed of flat steel bars welded together in a grid pattern. The bar screen is designed to allow free flow of effluent while removing large objects from the wastewater stream (13). Bar screens can be automatically or manually cleaned to remove the entrapped objects. If performed on a regular basis, manually cleaned bar screens are often the most cost-efficient (14).

Fine screening is performed using lint screens. These screens are constructed of wire mesh or perforated metal plates and are often installed downstream from bar screens. Lint screens are designed to remove lint and other particles, such as sand or grit, from wastewater (13). Hydrosieve or static screens are installed in the process wastewater line and trap the entrained particles as the water passes through the screen. Static screens must be routinely cleaned or changed out to prevent excessive clogging of the wastewater line. This task is often performed manually. The static screen is relatively inexpensive to maintain and operate.

Shaker and rotary screens are mechanically equipped to remove the entrained solids from the screen apparatus to ensure continuous operation. Shaker or vibratory screens operate by intermittently vibrating about the center of mass, forcing the solids from the screen surface, outward toward the periphery, and around to a port through which the solids are removed and collected in a sack or bin. These screens may also include accessories, such as brushes, rakes, and water sprayers, to remove solids and to enhance the performance of the continuous screen cleaning mechanism (15). Figure 6-2 presents a diagram of a shaker screen.

A rotary screen consists of a cylindrical screen that rotates within a chamber. The wastewater passes through the screen as it rotates and the solids are collected on the surface of the screen. The solids are removed from the screen surface by means similar to those of shaker screens (i.e., brushes or water sprays). The rotary screen can be operated either by passing the water from the outside of the rotating screen toward the center of the chamber, with solids collection on the exterior surface, or by passing the wastewater from the center of the chamber toward the exterior, with solids collection on the interior surface of the screen (11).

Most screens are placed at the beginning of the wastewater treatment train. Bar screens, in particular, are most often located at the end of the wastewater trenches that carry the water discharged from the wash room to the treatment system (if present) and the final discharge point. As stated in Section 6.5.1 of this document, EPA believes that all facilities have an initial catch/settling basin located at the end of the trench. Fine screening (either static or mechanical) may be performed either before or after the water is collected in the catch basin. The advantage to screening the water before initial collection is that the amount of solids that will settle and accumulate within the catch basin is reduced, lowering the maintenance costs associated with periodic cleaning of the catch basin.

Industry Application

The majority of in-scope industrial laundries (77 percent) perform at least one screening operation before discharging their wastewater (146 out of 190 in-scope facilities responding to the detailed questionnaire reported having a screen(s)). Thirteen facilities perform coarse screening only, using a bar screen.

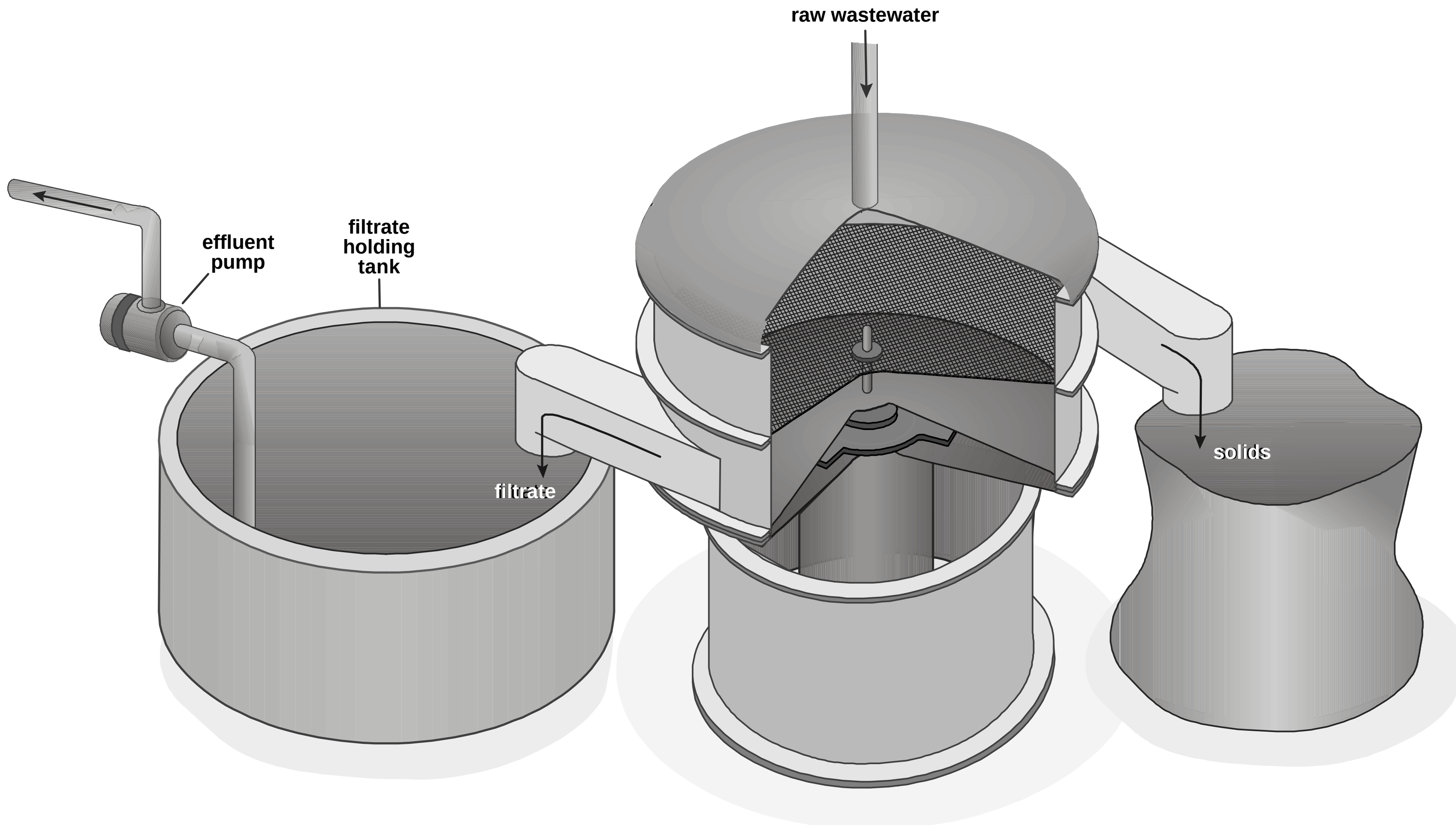

Figure 6-2. Shaker Screen

Forty-three facilities reported at least one type of static screen (e.g., lint screen, box screen, or strainer). The most prevalently used fine screen is the lint screen (reported by 38 facilities); box screen and strainer use was reported much less frequently.

More than half (52 percent) of the facilities reporting a screening operation have at least one mechanical screen. Ninety-two facilities reported having a shaker screen, six facilities reported having a rotary screen, and one facility reported having both types of mechanical screens

Five facilities use coarse screening with a static fine screen; six facilities use coarse screening with a mechanical fine screen; five facilities use both static and mechanical fine screening; and two facilities use all three types of screens: coarse, static fine, and mechanical fine screening.

6.5.4 Equalization

General Description

Equalization is used to control fluctuations in flow and pollutant loadings in process wastewater prior to treatment to overcome operational problems that may result from the fluctuations, reduce the size and cost of the downstream treatment units, and improve the overall performance of these units. Equalization systems are typically designed to eliminate variations in the wastewater, (e.g., flow, pollutant load, and pH) by retaining the wastewater until it can be discharged at a constant rate having uniform characteristics. In this way, facilities can size and operate the downstream treatment units on a continuous-flow basis with minimal disruption in the treatment conditions. The amount of time required to achieve optimum effects depends upon the specific characteristics and daily flow patterns of the wastewater. Equalization units are often equipped with agitators (e.g., impeller mixers and air spargers) to further mix the wastewater and to prevent excessive solids settling at the bottom of the unit. Chemicals may also be added to the equalization units to adjust the pH and otherwise prepare the wastewater for further treatment (16). Section 6.5.9 of this document (pH Adjustment) discusses equalization units that use pH-adjusting chemicals.

Industry Application

It was assumed that a facility reporting at least one vessel from which no solids are collected and to which no chemicals were added had equalization. Fifty-two percent of the in-scope industrial laundries responding to the detailed questionnaire (98 of 190) reported treating their wastewater through equalization. Thirty percent of these facilities reported using at least one mixer to agitate the wastewater. The equalization units reported in the detailed questionnaire have an average residence time of 7.6 hours.

6.5.5 Chemical Emulsion Breaking

<u>General Description</u>

Chemical emulsion breaking is used primarily to remove oil and grease, as well as other related pollutants, from process wastewater streams. Chemical emulsion breaking is effective in treating wastewater streams having stable oil-in-water emulsions. In a stable emulsion, oil is dispersed within the water by way of attractive electrical charges that exist, often as a result of other constituents (e.g., emulsifying agents and surfactants) present in the water. These emulsions require acid addition to lower the pH of the wastewater and neutralize the electrical charges between the oil and water, enabling the oil to form a distinct and separate phase within the water. Chemical emulsion breaking units add demulsifying agents to aid in forming the oil phase and subsequently remove it from the wastewater stream.

Various reactive cations are effective as demulsifying agents to break emulsions (e.g., hydrogen (H +1), aluminum (Al +3), and iron (Fe +3)). Sources of these cations include acids, alum, ferrous salts, and various cationic polymers. The demulsifier is added to the wastewater stream and allowed to react with the water long enough to cause the oil to agglomerate to form a distinct oil phase. Mechanical mixing increases the effectiveness of the demulsifier by dispersing the chemical into the water rapidly and uniformly. Mixing also aids demulsification by causing molecular collisions that help agglomerate oil droplets and subsequently help to break the emulsion.

In batch-mode units, the treated wastewater is allowed to stand long enough to allow the oil droplets, having a lower specific gravity, to rise and form a layer on the surface. This layer may be removed by controlling the water level within the unit, such that the oil layer is raised above a weir and overflows into the collection unit while water underflows the weir. The oil layer may also be removed by manually or mechanically raking the surface over a weir with a skimming device.

Skimming devices typically work by continuously contacting the oil with a material, usually an oleophilic belt or rope, onto which the oil readily adheres. As the material passes through the oil layer, the oil coats the surface of the material. The oil-coated material then passes through a mechanism that scrapes the oil from the material into an oil-collection unit. This process uses a motorized drive to continuously remove oil from the wastewater surface. Figure 6-3 presents a diagram of a batch chemical emulsion breaking unit. Batch chemical emulsion breaking systems can remove significant amounts of oil and grease from process wastewater, if they are designed with optimized residence times and the oil-removal devices are properly operated and maintained.

Continuous chemical emulsion breaking units are equipped with various hydrodynamic structures that physically separate entrained oil droplets from wastewater and pump them to a collection unit while allowing the water to pass through without interruption. These units usually comprise a series of corrugated and/or inclined plates arranged parallel to one another and transverse to the flow of water. They are often built of materials that attract oil away from the water. As the oil droplets impinge on the surfaces of the plates, they coalesce into a

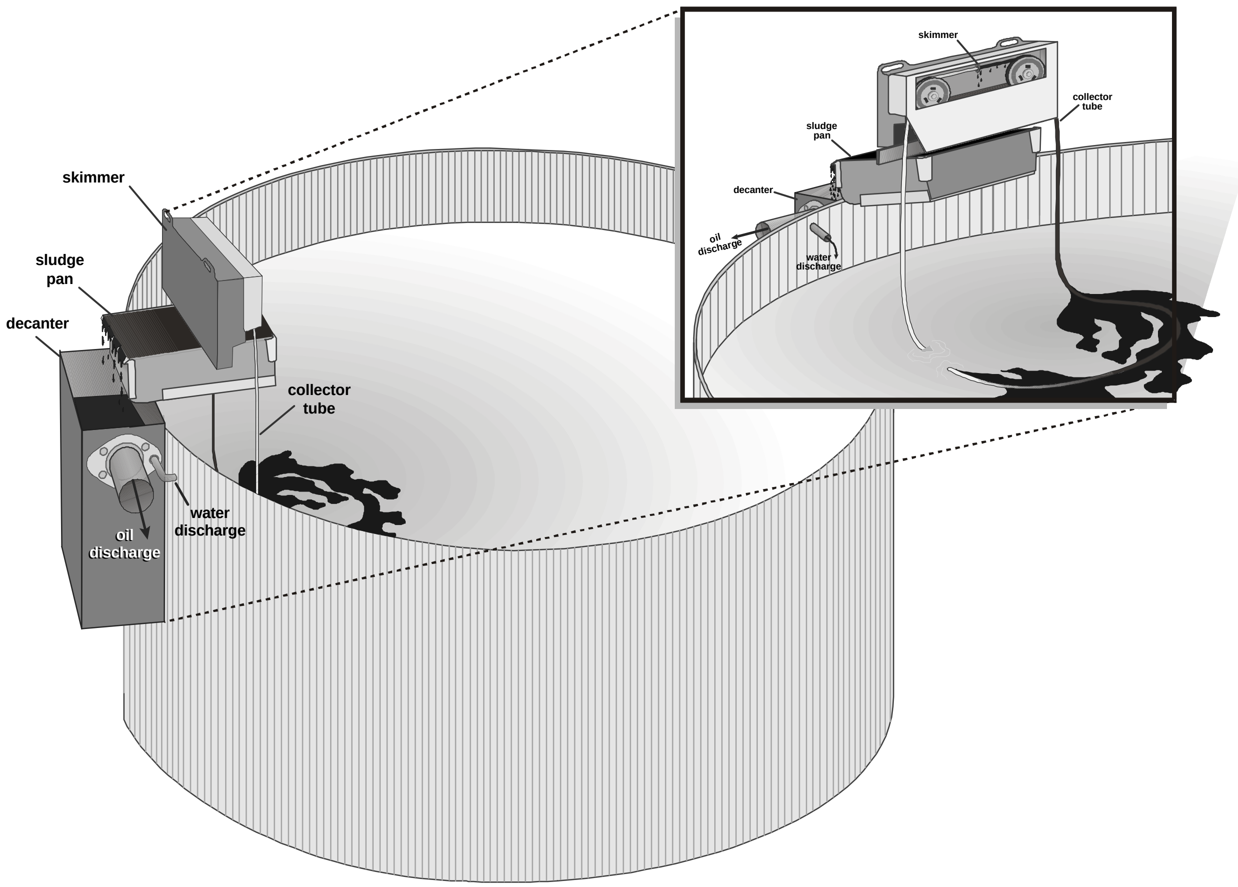

Figure 6-3. Batch Chemical Emulsion Breaking Unit

layer of oil that flows or is pumped from the unit. Figure 6-4 presents a diagram of a continuous chemical emulsion breaking unit with coalescing plates.

Continuous chemical emulsion breaking units do not require long residence times, as do batch systems, and thus are more compact and space efficient. However, they do require uniform wastewater conditions in terms of flow rate and oil and grease loads, which may not be easily achieved in some wastewater treatment systems. In addition, the plates often require routine maintenance to ensure proper operation and to prevent clogging. The effectiveness of batch or continuous systems is highly dependent upon the specific characteristics of the process wastewater (17).

Industry Application

Nine of the 190 in-scope industrial laundry facilities responding to the detailed questionnaire reported treating their wastewater through chemical emulsion breaking and adding acid as a demulsifying agent. Rope skimmers, decant tanks, and gravity separation were reported most frequently (at six of the facilities) to collect the demulsified oil from the surface of wastewater. These six facilities demulsify the oil in a batch process with a median residence time of seven hours. The remaining three facilities run chemical emulsion breaking continuously, using coalescing plates or plate separators. These continuous-process chemical emulsion breaking units have a much lower median residence time (less than one hour). Six of the facilities demulsify all of their process wastewater, and three demulsify only heavy wastewater (the portion of the wastewater with the highest concentration of contaminants). Chemical emulsion breaking is often used as a pretreatment to other technologies; four of the nine facilities reported using chemical emulsion breaking as a pretreatment to either dissolved air flotation (three facilities) or chemical precipitation (three facilities). Eight of the nine facilities that use chemical emulsion breaking reported disposing of the demulsified oil at an oil reclaimer.

Some facilities responding to the detailed questionnaire reported using oil/water separation technologies without adding demulsifying agents to their wastewater. Oil/water separation and the facilities performing this treatment are described in Section 6.5.12 of this document.

6.5.6 Chemical Precipitation

General Description

Chemical precipitation is one of the most commonly used processes in water treatment (18). Specifically, chemical precipitation is used to remove organics, oils, and dissolved pollutants from process wastewater. Precipitation aids, such as lime, work by reacting with the cations (e.g., metals) and some anions to convert them into an insoluble form (e.g., metal hydroxides). The pH of the wastewater affects how much pollutant mass is precipitated, as various pollutants will precipitate only within specific pH ranges. Therefore, the pH of the wastewater is often increased to facilitate maximum pollutant precipitation. Lime and other caustic materials increase the pH of the wastewater stream and react with the dissolved ions to form insoluble compounds, making them good precipitation aids (17).

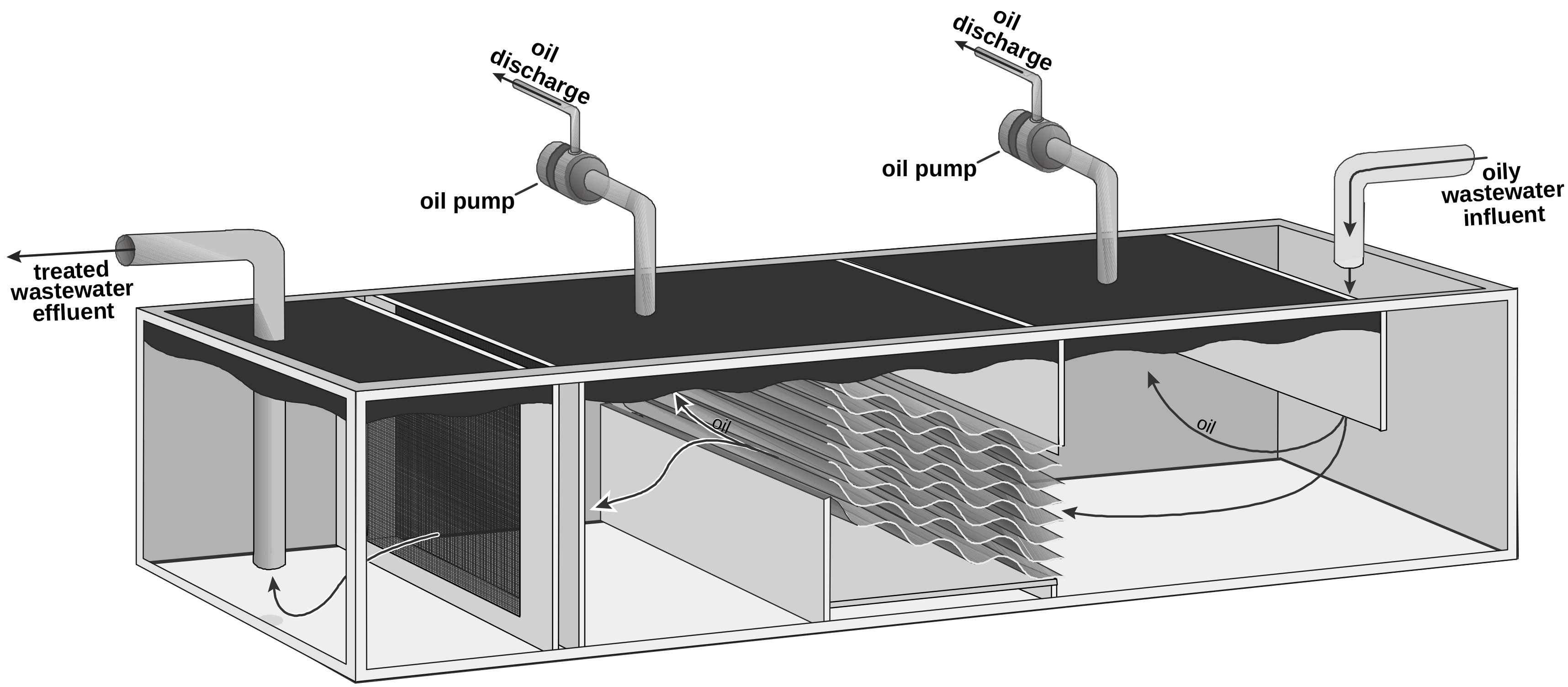

Figure 6-4. Continuous Chemical Emulsion Breaking Unit with Coalescing Plates

In chemical precipitation units, coagulation and flocculation aids are usually added to facilitate the formation of large agglomerated particles that are simpler to remove from the wastewater. The precipitants as well as other suspended solids often have like or neutral surface charges that repel one another. Coagulants bind to the particles in the wastewater stream and essentially convert the surface charges; as a result, opposite charges form between the particles, which causes them to agglomerate. Examples of coagulants include cationic polymers and various inorganic salts, such as ferric chloride ($FeCl_3$), and aluminum sulfate or alum ($Al_2(SO_4)_3 \bullet 18\ H_2O$). Flocculent aids, typically anionic polymers, are added to further enhance the agglomeration of the particles (16).

Like chemical emulsion breaking units, chemical precipitation units may use various mechanisms to remove the agglomerated floc from the wastewater. In batch chemical precipitation systems, the treated wastewater is held in the unit long enough to allow the solids to settle out. The water is then pumped from the unit, and the remaining sludge is removed for further dewatering and subsequent disposal. Figure 6-5 presents a diagram of a batch chemical precipitation system. In a batch system, chemical addition and residence time are easily adjusted based on the particular conditions of the process wastewater. Batch systems usually require the use of two water-holding units connected in parallel (i.e., one is used to treat the process wastewater while the other collects the wastewater to be treated in the next batch) and therefore generally require more space than continuous systems.

Continuous units often use hydrodynamic structures that push the solids downward as the water flows past. These structures usually comprise a series of parallel plates arranged tangentially to the flow of water. As the water flows between them, the heavy particles impinge against the plates and lose enough momentum that they are forced to sink to the bottom of the unit. Continuous units also include pumps or augers that remove the settled solids from the unit. Because of their single unit design and relatively short required retention time, continuous chemical precipitation units are space efficient. However, the performance of continuous systems can be disrupted if wastewater conditions are varied. Figure 6-6 presents a diagram of a continuous chemical precipitation system.

Industry Application

Eleven percent of the in-scope industrial laundry facilities responding to the detailed questionnaire (21 of 190) reported treating their wastewater using chemical precipitation. These can be divided into two groups: facilities that use chemical precipitation to treat their entire wastewater stream (16 facilities) and facilities that use chemical precipitation to treat only a portion of the wastewater stream generated from laundering of heavily soiled items such as shop towels (5 facilities).

Chemicals added during chemical precipitation include lime, anionic polymers, and cationic polymers. Facilities using chemical precipitation fall into two categories, or "schemes," depending on the chemicals added during chemical precipitation.

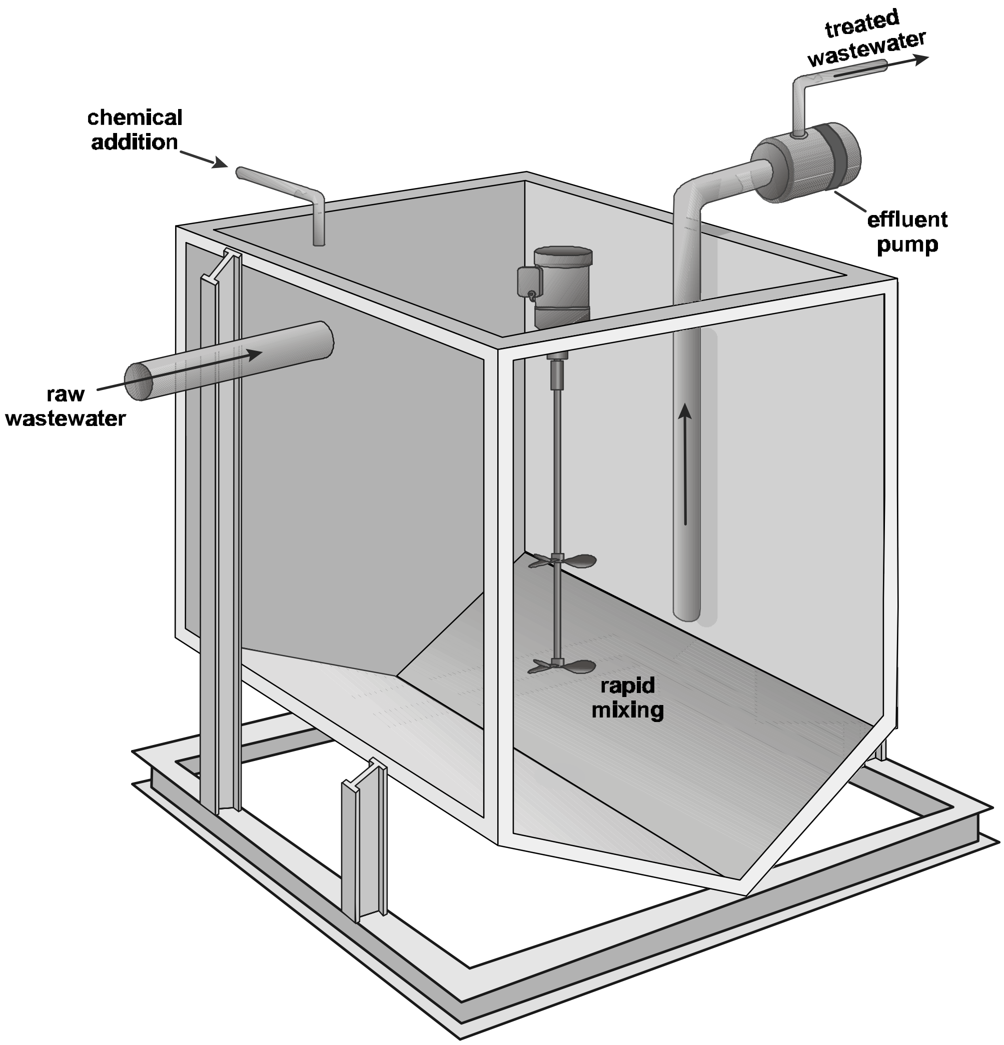

Figure 6-5. Batch Chemical Precipitation System

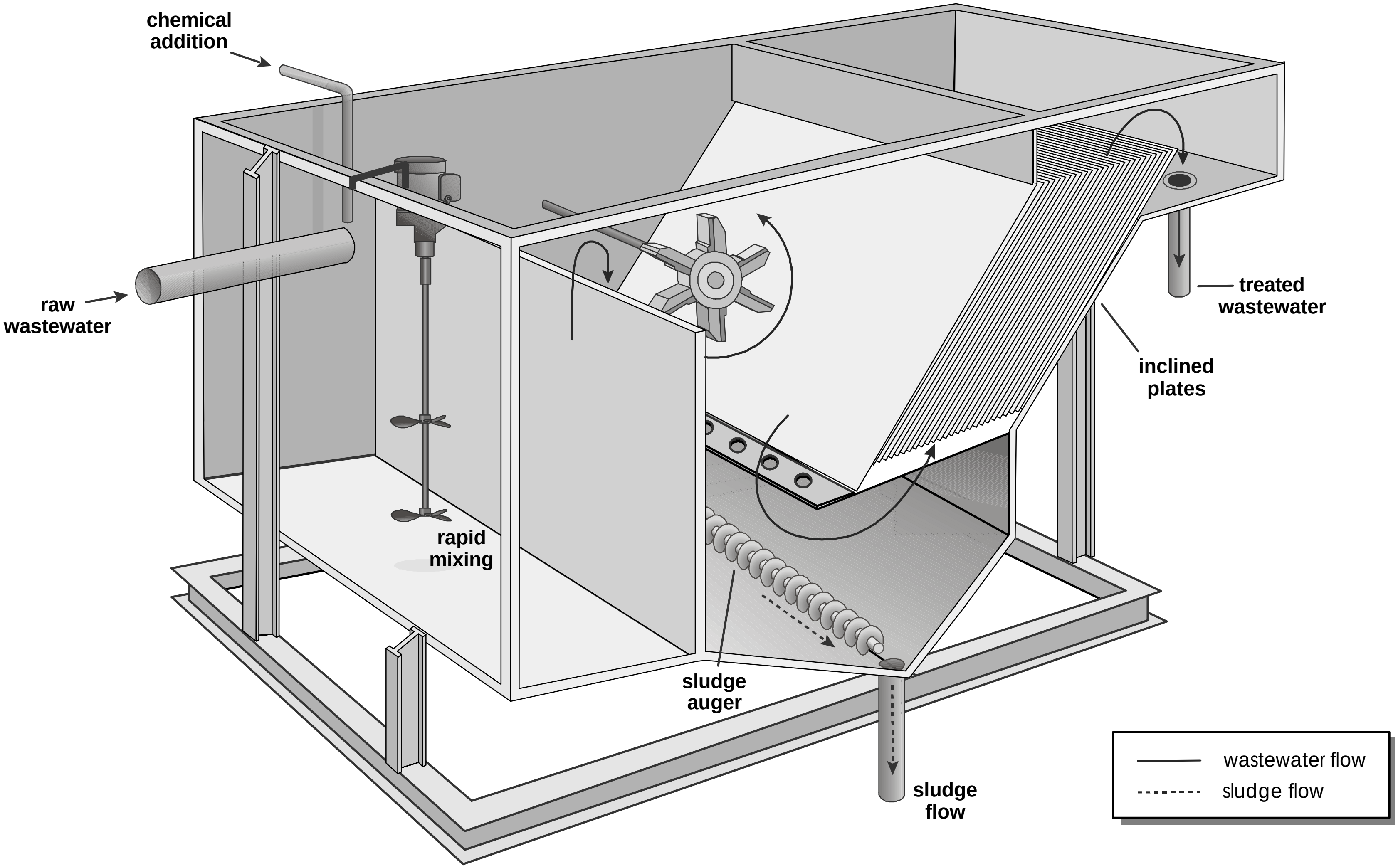

Figure 6-6. Continuous Chemical Precipitation System

The following table shows the distribution of facilities within each scheme that either treat only the portion of their wastewater stream generated from laundering heavily soiled items or their entire wastewater stream.

Scheme	Chemicals Added	Number of Facilities Treating Only Heavy Waste Stream	Number of Facilities Treating Entire Waste Stream
Scheme A	Polymer, lime	4 (13%)	6 (29%)
Scheme B	Polymer	1 (5%)	10 (48%)

There are 18 facilities using chemical precipitation that reported operating a continuous treatment unit. Three facilities reported using a batch chemical precipitation operation.

6.5.7 Dissolved Air Flotation (DAF)

General Description

Dissolved air flotation (DAF) is used to remove suspended solids, emulsified oil, and some dissolved pollutants from process wastewater. DAF treatment involves coagulating and agglomerating the solids and emulsified oil and floating the resulting floc to the surface using pressurized air injected into the unit. During this process, chemicals such as ferric and aluminum salts, activated silica, and cationic polymers are typically added to alter the repellant surface charges of the particles in the wastewater and cause them to agglomerate (13). Certain dissolved pollutants (e.g., metals) may be precipitated by reacting with the inorganic salts to form insoluble particles that also agglomerate with the floc. Flocculent aids (typically anionic polymers) are also added to DAF treatment systems to further enhance the formation of large particles.

DAF uses a dissolved air stream injected into the bottom of the unit to provide the flotation mechanism. Air is injected into a water tank under sufficient pressure to dissolve the air within the water. As the water is injected into the DAF unit, the pressure is decreased and the air is brought out of solution, creating many small bubbles. The large floc particles attach to the rising bubbles and are brought to the surface of the unit. Injected air flotation (IAF) systems (also referred to as induced air flotation) work in a similar fashion, but do not use pressurized air. Instead, the air is injected directly into the IAF unit. DAF units use rakes that scrape the floc from the surface and into a sludge collection vessel, where it is subsequently pumped to a dewatering unit and later disposed of. Some solids are expected to settle to the bottom of the unit; therefore, some units also have bottom sludge removal rakes or augers (13).

DAF is used in the water treatment industry to remove fat, oils, fibers, and grease from wastewater and algae from nutrient-rich reservoir water. DAF is commonly used to treat water when sedimentation treatment proves ineffective. Water with low turbidity or low alkalinity or colored water may not be effectively treated through sedimentation. DAF units are typically operated on a continuous basis and incorporate the chemical mix tanks, flotation vessels, and sludge collection into a single unit. Figure 6-7 presents a diagram of a DAF unit.

Industry Application

Eighteen percent of the in-scope industrial laundry facilities responding to the detailed questionnaire (35 of 190) reported treating their wastewater using DAF. All of these facilities add chemicals to the DAF and collect the DAF float sludge. (Two additional facilities that reported using DAF were excluded because they do not collect float sludge.) In addition, 10 of the facilities reported that they also collect bottom sludge.

Chemicals added to the DAF unit include sulfuric acid, inorganic coagulants (metal salts), anionic polymers, cationic polymers, and flocculents. Facilities using DAF fall into four categories, or “schemes,” depending on the chemicals added during treatment:

Scheme	Chemicals Added	Number of Facilities Treating Waste Stream
Scheme A	Polymer, inorganic coagulant (e.g., metal salt)	11 (31%)
Scheme B	Polymer	9 (26%)
Scheme C	Polymer, flocculent	7 (20%)
Scheme D	Polymer, flocculent, inorganic coagulant (e.g., metal salt)	6 (17%)

Note: EPA did not receive treatment chemical information for all of the DAF facilities, so the total does not add up to 100 percent.

Thirteen facilities also add sulfuric acid to the wastewater before it enters the DAF unit.

6.5.8 Sludge Dewatering

General Description.

Sludge dewatering processes remove water from sludge that is generated from the wastewater treatment process. Sludge dewatering provides the following benefits to a facility’s operations:

- Substantially reduces the costs for sludge disposal by reducing the sludge volume;
- Allows for easier handling than thickened or liquid sludge; dewatered sludge may be transported via manual shoveling, tractors fitted with buckets and blades, and belt conveyors;
- Reduces the requirements for supplemental bulking agents or amendments added to sludge prior to composting;

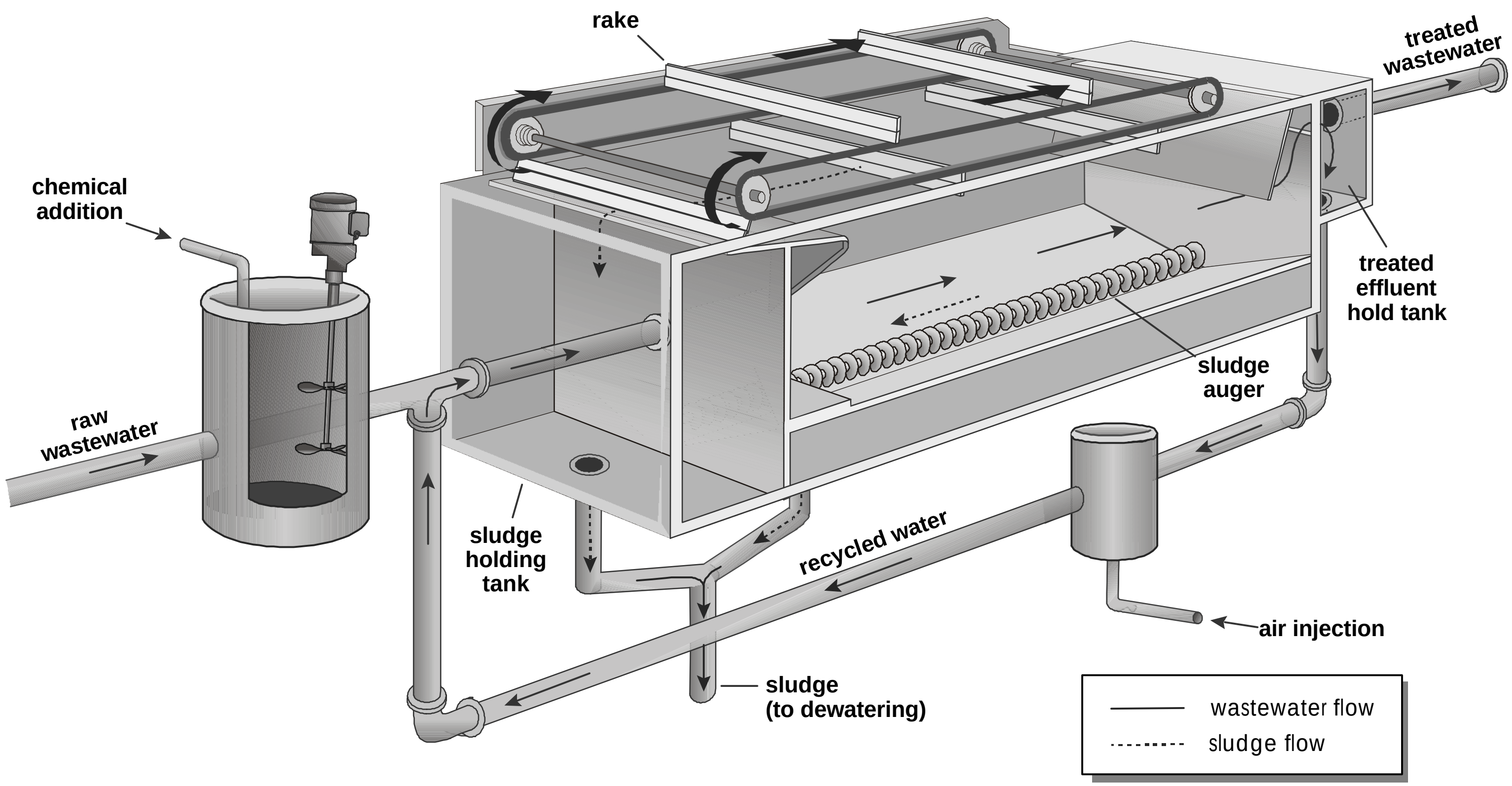

Figure 6-7. Dissolved Air Flotation Unit

- May be a requirement for sludge disposal to render the sludge odorless and nonputrescible; and

- May be a requirement for landfill disposal of sludge to reduce leachate production at the landfill site (11).

Dewatering may involve simple techniques, such as natural evaporation or drying of sludge using heat. Various mechanical techniques may also be used to remove water from sludge more rapidly, such as filtration, squeezing, capillary action, vacuum withdrawal, and centrifugal separation and compaction (11). The two most prevalent mechanical dewatering devices reported in the industrial laundries industry are the rotary vacuum filter and the plate and frame filter press.

The rotary vacuum filter is a cylindrical drum with a filter medium (e.g., natural fiber cloth or screen) around its perimeter. The drum is horizontally suspended within a vessel and is partially submerged in the sludge. The drum is rotated and the drum filter surface contacts the sludge within the vessel while a vacuum is drawn from within. This draws the water through the filter medium from the outside of the drum toward the axis of rotation and discharges it through a filtrate port. The solids become trapped against the filter medium, forming a dewatered filter cake around the outside of the drum. Rotary vacuum filters typically include a knife or a blade, which continuously scrapes the dewatered cake from the outside of the drum and into a collection bin. These types of filters can obtain a reasonably dry cake appropriate for disposal; however filter aid materials (e.g., diatomaceous earth or perlite) are usually required to precoat the filter (11). Figure 6-8 presents a diagram of a rotary vacuum filter.

Filter presses use positive pressure to drive the water through the filter medium. This type of unit comprises a series of recessed plates affixed with a filter medium (e.g., filter cloth) that are stacked together horizontally on a frame. During operation, the plates are forced together by a hydraulic ram or powered screw. The plates form a series of spaces separated by the filter medium and are otherwise sealed to withstand the internal pressures created during the filtration cycle. As the sludge is forced through the system, the water passes through the filter medium and is discharged through the filtrate port while the solids become trapped within the spaces, forming a dewatered cake against the filter medium. When the cycle is over, the plates are separated and the dewatered cake is released into a collection bin. The operator often has to remove the cake from the filter medium manually. Filter presses are usually able to achieve a drier filter cake than rotary drum filters and do not require precoating with a filter aid. The filtrate that results from either of these operations is usually piped back to the beginning of the treatment system or is simply discharged with the effluent water. Figure 6-9 presents a diagram of a filter press.

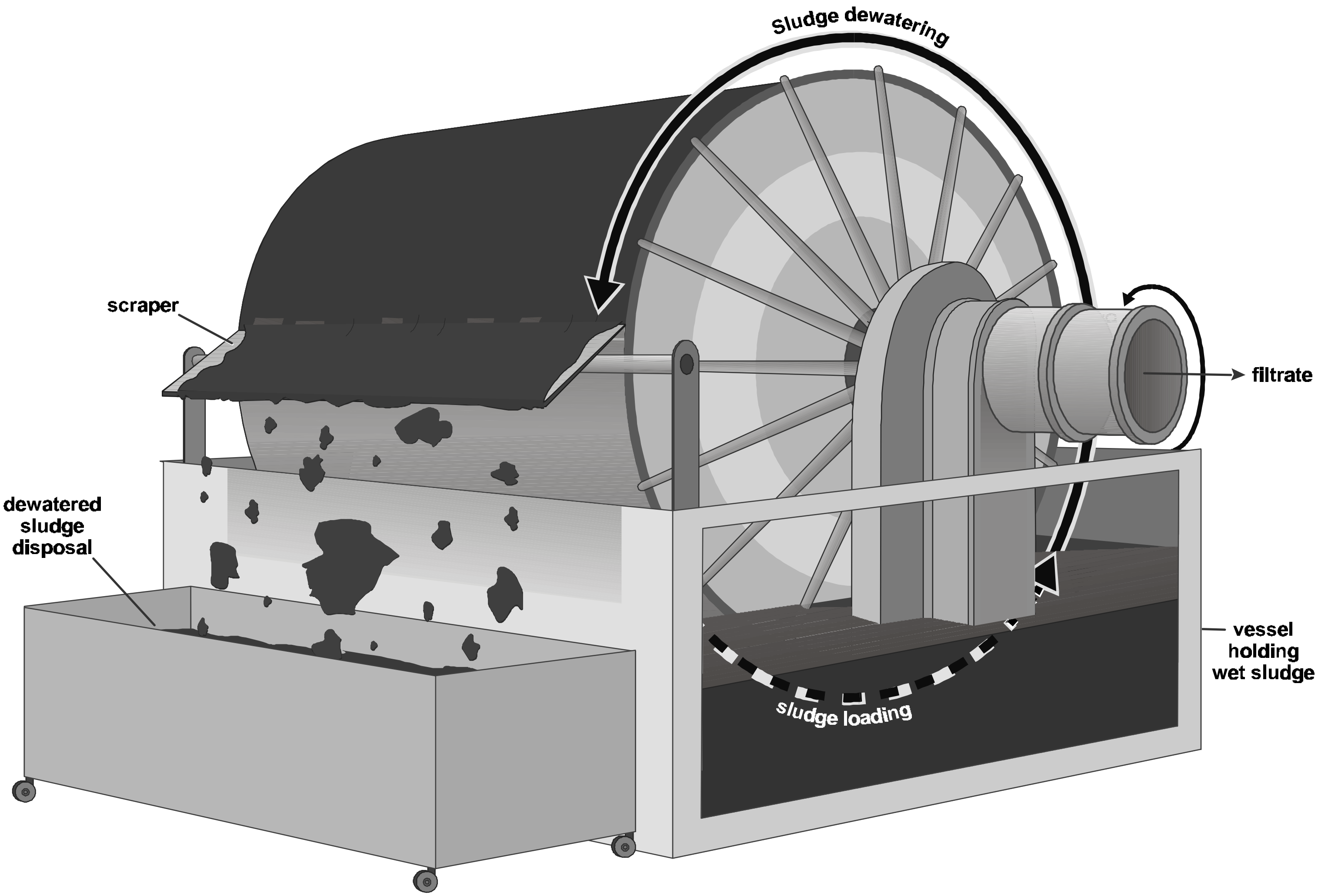

Figure 6-8. Rotary Vacuum Filter

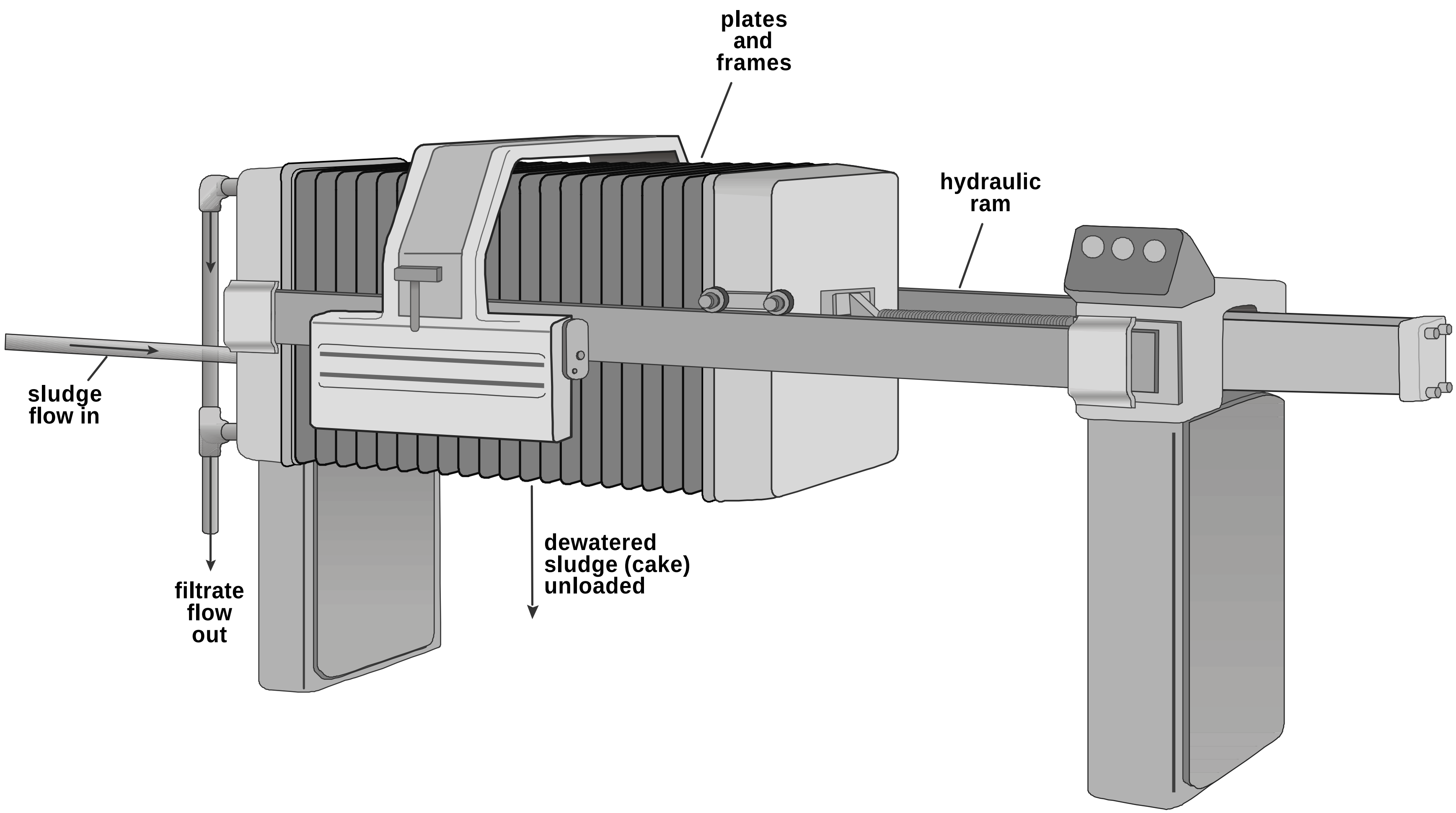

Figure 6-9. Filter Press

Industry Application

Twenty-seven percent of the in-scope industrial laundry facilities responding to the detailed questionnaire (52 of 190) reported dewatering their sludge before disposal. The types of dewatering devices reported include:

Dewatering Device	Number of Facilities
Plate and frame filters	32 facilities (62%)
Rotary vacuum filters	12 facilities (23%)
Sludge dryers	3 facilities (6%)
Bag filters	2 facilities (4%)
Other	4 facilities (8%)

Note: One facility reported both a rotary vacuum filter and a sludge dryer.

In the industrial laundries industry, most of the sludge that is dewatered comes from DAF or chemical precipitation units. More than half of the dewatering devices (27 of 52 facilities) process sludge from a DAF unit. Sixteen dewatering devices process sludge from a chemical precipitation unit. The remaining dewatering devices process sludge from other sources.

Characteristics of industrial laundry sludge are highly dependent on the items washed, water conditions, and upstream treatment. Facilities responding to the detailed questionnaire that generate sludge reported an average solids content of 17 percent for the undewatered sludge. Facilities that dewater a sludge reported an average solids content of 40 percent for the dewatered sludge.

Fifty-four percent of facilities that dewater sludge add one or more chemicals that aid in dewatering. The chemicals commonly added to aid in industrial laundry sludge dewatering are:

Chemical Added	Number of Facilities
Lime	12 (43%)
Polymer	10 (36%)
Diatomaceous earth	5 (18%)
Perlite	5 (18%)
Ferric chloride	3 (11%)

Note that facilities that add more than one chemical are represented twice in the above table.

6.5.9 pH Adjustment

General Description

Because many treatment technologies used in the industrial laundries industry are sensitive to pH fluctuations, pH adjustment may be required as part of an effective treatment system. In addition, the pH of the final effluent from these technologies must often be adjusted prior to discharge to meet POTW regulatory limits. A pH adjustment system normally consists of a small tank in which the wastewater pH is adjusted by chemical addition controlled by a pH meter and mixing. To adjust the pH of the wastewater, either caustics or acids are added to the mixing tank. Some treatment technologies require a high pH (e.g., chemical precipitation), while others require a low pH (e.g., chemical emulsion breaking).

Industry Application

It was generally assumed that facilities reporting at least one vessel into which either acid or base was added had pH adjustment. Twenty-two percent of in-scope facilities responding to the detailed questionnaire (42 of 190) reported treating their wastewater with pH adjustment. Several industrial laundries reported operating more than one pH adjustment unit. Therefore, the facilities responding to the questionnaire reported operating a total of 46 pH adjustment units. Acid (usually sulfuric) is added to the pH adjustment unit most frequently (41 of 46). However, sodium hydroxide (4 of 46), and lime (2 of 46) are also added to the pH adjustment units. Seventy percent of the pH adjustment units discussed in the detailed questionnaire (32 of 46) have one or more mixers. The average residence time of all 46 units at the 41 facilities is 2.1 hours.

6.5.10 Ultrafiltration/Microfiltration

General Description

Ultrafiltration and microfiltration use semipermeable polymeric membranes to separate emulsified or colloidal materials suspended in the process wastewater stream by pressurizing the wastewater so that it permeates the membrane. The membrane of an ultrafilter or a microfilter forms a screen that retains molecular particles based on their differences in size, shape, and chemical structure. The membrane allows solvents and lower molecular weight molecules to pass through.

In an ultrafiltration or microfiltration process, the wastewater is pumped through the membrane. Water and some low-molecular-weight materials pass through the membrane under the applied pressure (e.g., 10 to 100 psig). Emulsified oil droplets and suspended particles are retained, concentrated, and removed continuously (17). Ultrafiltration and microfiltration have the benefit of removing entrained solids and oils from wastewater with lower capital costs than chemical treatment (19). However, the limitations of the technologies include fairly narrow optimum operating conditions in terms of pH and temperature. In addition, if the wastewater has a high concentration of suspended solids, the wastewater will require substantial pretreatment to remove the solids to avoid excessive clogging of the membrane and increased maintenance costs.

Industry Application

One facility responding to the detailed questionnaire reported operating an ultrafiltration unit and one facility reported operating a microfiltration unit (one percent total). EPA has since contacted these facilities to determine the effectiveness of ultrafiltration/ microfiltration in treating industrial laundry wastewater. At the facility reporting use of the ultrafiltration unit, facility personnel reported that the ultrafiltration unit effectively treats wastewater generated at the facility. The filter membrane was changed out after 4.5 years of operation in 1997. Facility personnel did not report difficulties with membrane clogging. The wastewater from the facility is treated with a screen and pH adjustment prior to the ultrafiltration unit. At the facility reporting use of the microfiltration unit, facility personnel reported that they have since discontinued use of the microfiltration unit because the microfilter clogged whenever wastewater containing high levels of oil and grease was treated. Because of this clogging, the facility could not attain the required flow rate through the microfiltration unit.

6.5.11 Centrifugation

General Description

Centrifugation applies centrifugal forces to settle and separate higher density solids from process wastewater. The two most common types of centrifuges are the solid bowl decanter and the basket-type centrifuge. The solid bowl decanter consists of a long bowl, mounted horizontally and tapered at one end. The sludge or wastewater is introduced at one end continuously while the bowl rotates, and solids concentrate on the inner wall of the bowl as a result of the centrifugal forces caused by the bowl's rotation. A helical scroll, spinning at a slightly different speed, moves the accumulated sludge toward the tapered end. The sludge is then discharged. The basket centrifuge operates on a batch basis. The sludge or wastewater is introduced into a vertically mounted spinning bowl. The solids accumulate against the wall of the bowl and the water is decanted by being forced over the bowl's outer lip. When the bowl has reached its capacity in solids collection, the spinning is stopped and a scraper is used to remove the solids. The basket-type centrifuge is well suited for sludges containing fine solids that are difficult to filter or where the nature of the solids varies widely (11).

Centrifugation may be combined with certain wastewater treatment chemicals that act to bring additional pollutants out of solution and form an insoluble floc (e.g., as in chemical precipitation) that is also separated from the wastewater by the centrifugal forces.

Industry Application

Three percent of in-scope industrial laundries responding to the detailed questionnaire (6 of 190) reported treating their wastewater with centrifugation. Two of these facilities treat their wastewater with chemical precipitation and use centrifugation to remove the sludge from the treated wastewater. The remaining four facilities reported using centrifuges to remove lint from their raw wastewater. While only five of the six facilities reported removing sludge generated during centrifugation, EPA believes that all facilities treating their wastewater with centrifugation remove the sludge generated.

6.5.12 Oil/Water Separation

General Description

Like chemical emulsion breaking units, oil/water separators are used primarily to remove oil and grease, as well as other related pollutants, from process wastewater streams. Oil/water separators are similar to batch chemical emulsion breaking units except that no chemicals are added to an oil/water separator to enhance separation.

During oil/water separation, the wastewater is allowed to stand long enough to allow the oil droplets, having a lower specific gravity, to rise and form a layer on the surface. This layer may be removed by controlling the water level within the unit, such that the oil layer is raised above the weir and overflows into the collection unit while water underflows the weir. The oil layer may also be removed by manually or mechanically raking the surface over a weir with a skimming device.

Skimming devices typically work by continuously contacting the oil with a material, usually an oleophilic belt or rope, onto which the oil readily adheres. As the material passes through the oil layer, the oil coats the surface of the material. The oil-coated material then passes through a mechanism that scrapes the oil from the material into an oil-collection unit. This process uses a motorized drive to continuously remove oil from the wastewater surface. The skimming device shown in Figure 6-3 is similar to the type of skimming device used in oil/water separators.

Industry Application

Thirteen percent of industrial laundries responding to the detailed questionnaire (24 of 190) report treating their wastewater through oil/water separation. None of these facilities add demulsifying agents (e.g., acid) to their wastewater and are therefore not considered to treat their wastewater with chemical emulsion breaking, as described in Section 6.5.5 of this document. These facilities employ various devices to remove the oil that has risen to the surface of the wastewater. These include:

- Oil skimmer (63 percent);
- Oil mop (17 percent);
- Coalescer (13 percent); and
- Decanter (4 percent).

The average residence time of the wastewater in the oil/water separation units is 8.5 hours.

6.5.13 Media Filtration

General Description

Media filtration is used primarily to remove suspended solids from process wastewater streams. During the filtration process, wastewater flows through a filter medium causing solids suspended in the water to become trapped in the medium. Filter media are usually beds of granular particles such as sand, anthracite, garnet, or carbon. The speed at which wastewater flows through the filter medium controls the size and number of suspended particles removed from the wastewater stream. To control the wastewater flow rate through the filter medium, the wastewater may flow horizontally or vertically through the filter bed, or the wastewater may be pumped under pressure through the filter bed.

As wastewater flows through the filter medium, suspended solids removed from the wastewater become trapped in the interstitial spaces between the granular particles of the filter bed. Over time, this may cause the filter medium to become clogged. Therefore, some media filtration units may be periodically backwashed to unclog the filter medium.

Industry Application

Ten of the 190 in-scope industrial laundries responding to the detailed questionnaire (five percent) reported operating a media filtration unit. Two of these facilities reported operating two media filtration units, resulting in 12 total media filtration units operated by the in-scope industrial laundries responding to the detailed questionnaire. Sand was the most commonly filter medium reported (7 of 12; 58 percent). Four media filtration units used sand alone (33 percent); three media filtration units operated with sand, anthracite, and garnet as the filter media (25 percent). Seventeen percent of the media filtration units (2 of 12) used cloth as the filter medium. One media filtration unit operated with carbon as the filter medium. Another media filtration unit operated with clay as the medium. The final media filtration unit operated with metal filings as the medium. Ninety-two percent of the media filtration units (11 of 12) operate under pressure. Eight media filtration units are periodically backwashed to prevent clogging of the filter media. All seven sand media filtration units and the metal filings media filtration unit are periodically backwashed. Facilities operating media filtration with backwash reported an average backwash cycle of 10 minutes, which occurs an average of three times per day.

6.5.14 Carbon Adsorption

General Description

Carbon adsorption uses activated carbon to remove dissolved VOCs from process wastewater. Activated carbon consists of an amorphous form of carbon that has been specifically treated with an oxidizing gas to form a highly porous structure having a large internal surface area. Granulated forms of this carbon are often used in a fixed-bed column. The wastewater is admitted into the unit from the top and is allowed to flow downward though a bed of the granulated activated carbon that is held in place within the column. As the water comes in contact with the activated carbon, the dissolved VOCs adsorb onto the surface of the activated carbon. Figure 6-10 presents a diagram of a fixed-bed activated carbon adsorption column.

As the activated carbon becomes increasingly saturated with VOCs, the effectiveness of the unit decreases and the carbon must be regenerated. In this process, the spent activated carbon is oxidized which removes the adsorbed VOCs from the surfaces. This process may destroy some of the activated carbon and decrease the performance of the rest. Therefore, the activated carbon must be periodically replaced for the adsorption unit to continue to operate effectively.

To maximize the performance and life of the activated carbon bed, all materials contained in the wastewater (e.g., suspended particles and heavy organics) that may foul the bed by “clogging” the pores of the carbon particles must be removed prior to this treatment process. In addition, the performance of the units may be improved by periodically backflushing the units. Fixed-bed carbon adsorption units may be operated singly, in series, or in parallel.

<u>Industry Application</u>

Two of the 190 industrial laundries (one percent) reported operating activated carbon adsorption columns to remove VOCs from their process wastewater.

6.5.15 Air Stripping

<u>General Description</u>

Air stripping is usually performed in a countercurrent, packed tower or tray tower column. The wastewater is introduced at the top of the column and allowed to flow downward through the packing material or trays. Air is simultaneously introduced at the bottom of the column and blows upward through the water stream. Volatile organics are stripped from the water stream, transferred to the air stream, and carried out of the top of the column with the air. The treated water is discharged out of the bottom of the column. Because the air stream now contains the VOCs, an air emission control device (e.g., a carbon adsorption unit) may be required to remove the VOCs before the air is released to the atmosphere.

<u>Industry Application</u>

Three of the 190 in-scope industrial laundries responding to the detailed questionnaire (two percent) reported operating air strippers to remove VOCs from their process wastewater. However, through site visits EPA is aware that one of these facilities does not operate its air stripper.

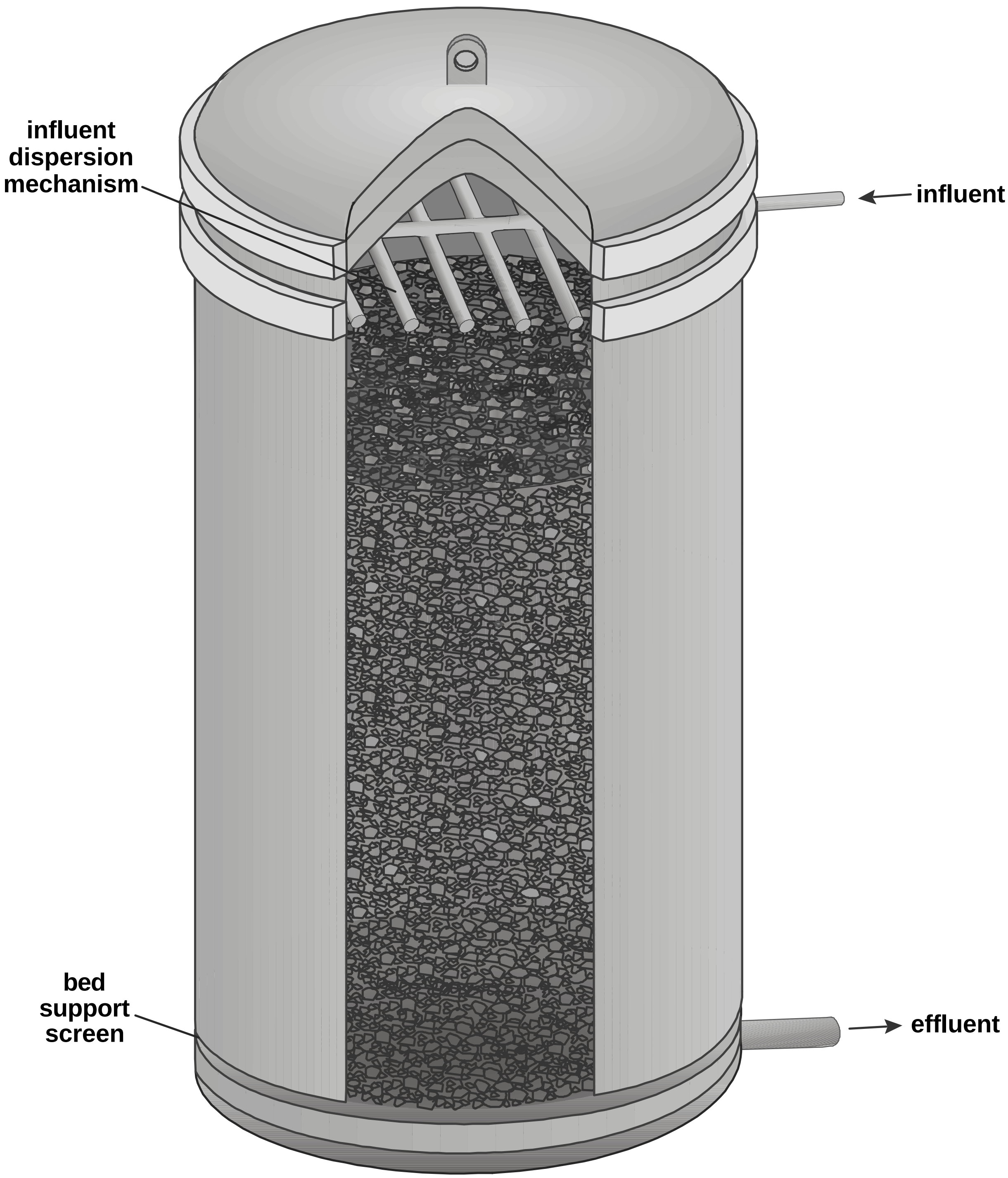

Figure 6-10. Fixed-Bed Activated Carbon Adsorption Column

6.5.16 Wastewater Treatment Technologies Used by the Industrial Laundries Industry in 1998

As discussed in Section 3.7.2, the industrial laundries trade associations (the Uniform and Textile Service Association (UTSA) and the Textile Rental Services Association (TRSA)) solicited updated data on wastewater treatment practices from industrial laundries sent EPA's detailed questionnaire. Of the 190 in-scope facilities, 162 responded to the UTSA/TRSA survey. Table 6-7 summarizes the difference in the use of each major type of wastewater treatment (e.g., chemical emulsion breaking, DAF, and chemical precipitation) reported in the detailed questionnaire for the 1993 operating year and in the UTSA/TRSA survey for the 1993 operating year.

Because the treatment system descriptions reported in the survey often did not include design parameters or the portion of wastewater treated, EPA made several assumptions in order to use the data provided by the trade associations. EPA determined that 18 facilities that did not have treatment at the time of the detailed questionnaire subsequently installed wastewater treatment for all or part of their wastewater flow. Most facilities that have installed treatment since 1993 (13 of the 18) have installed DAF. Other types of treatment installed include chemical emulsion breaking (at two facilities), chemical precipitation (at two facilities), and biological treatment (at one facility) (20).

In addition, some facilities changed their main treatment technology since 1993: four facilities changed from chemical precipitation to DAF, one facility changed from chemical emulsion breaking to DAF, and one facility changed from microfiltration to chemical emulsion breaking (20).

6.6 <u>Pollution Disposal Practices in the Industrial Laundries Industry</u>

This section presents information on the various types of wastewater, solvent, and sludge wastes that may be generated at industrial laundries and the disposal practices reported in the detailed questionnaire or observed by EPA during site visits and sampling episodes.

6.6.1 Wastewater Disposal

All 190 in-scope industrial laundries responding to the detailed questionnaire reported discharging their wastewater to a publicly owned treatment works (POTW), a privately owned treatment works (PrOTW), a federally owned treatment works (FOTW), or a centralized treatment works (CTW). Three percent of the facilities discharging wastewater (5 of 190) also reported disposing of a portion of their wastewater by land application.

Contract hauling of facility wastewater, in lieu of on-site treatment, may be a cost-effective and technically feasible option for some industrial laundries. Wastewater to be hauled off site could be stored in above ground storage tanks and hauled off site in 5,000 gallon increments, which is the capacity of most vacuum tankers used to haul the wastewater.

Table 6-7

Comparison Between Treatment Technologies Reported in 1993 and 1998

Major Wastewater Treatment Unit Used and Portion of Wastewater Treated	Number of Facilities from EPA's 1994 Detailed Questionnaire	Number of Facilities from UTSA/TRSA's 1998 Survey
Chemical Emulsion Breaking	5	7
Chemical Precipitation of part of the facility's wastewater	5	4
Chemical Precipitation of all facility wastewater	12	11
Dissolved Air Flotation of part of the facility's wastewater	2	8
Dissolved Air Flotation of all facility wastewater	30	42
Microfiltration of part of the facility's wastewater	1	0
Ultrafiltration of all facility wastewater	1	1
No treatment	106	89[1]

[1]One facility from the UTSA/TRSA survey may be operating biological treatment.

The frequency of bulk wastewater pickups would depend on the amount of time required to generate 5,000 gallons of wastewater. The wastewater, handled as nonhazardous waste, may be hauled off site for treatment to a Treatment, Storage, and Disposal Facility (TSDF) or to a Centralized Waste Treater (CWT) (21). There were an additional 13 percent (25 of 190) that reported a very small portion of wastewater being shipped off site for disposal. However, it is believed that this wastewater is contained in the sludge collected from the treatment system and disposed off site.

6.6.2 Waste Organic Material Disposal

Some industrial laundries generate waste organic material that is either collected from incoming items or from the wastewater treatment system. Facilities that generate this type of waste launder heavily soiled items (e.g., shop towels, printer towels/rags, and furniture towels) as a large portion of their total production. By water washing these items, the organic material that was contained on them is transferred to the process wastewater. One method of collecting the waste organic material from the wastewater is through phase separation in equipment that is designed to collect the organic phase from the water. The wastewater may also be treated with chemicals that aid in removing emulsified organic material from the water. Many of these techniques were described previously in Sections 6.5.5 and 6.5.12 of this document. Some facilities also collect waste organic material that floats to the top of sludge collected from the wastewater treatment system (e.g., DAF or chemical precipitation). In some cases, industrial laundries may remove this waste organic material from the items prior to water washing, as described in Section 6.4 of this document.

Most industrial laundries dispose of the collected waste organic material by shipping it to off site hazardous waste disposal facilities for incineration or for fuel blending. In fuel blending, the waste organic material is mixed with other materials and used as a fuel. Theoretically, the incineration or fuel combustion process destroys the waste organic material.

In some cases, depending on the customer source and use of the items, the collected waste organic material may be pure enough to be reused, especially that collected from the items prior to water washing. Material that cannot be reused directly may need further processing in a distillation unit where the organic material is separated from other contaminating pollutants. The distillation is often performed by a commercial recycler but can also be performed on site at the industrial laundry facility. After distillation, the organic material may be reused by the industrial laundries' customers that use the items.

6.6.3 Sludge Disposal

Industrial laundries generate sludge from a variety of sources. These sources include trenches, catch basins, settling pits, or other structures that retain the process wastewater prior to discharge; shaker or rotary screens; and wastewater treatment units such as DAF or chemical precipitation that are designed to remove solids.

EPA believes that all laundries have trenches and at least one catch basin that receive the wastewater from the wash room prior to treatment (if present) or discharge.

Depending on the retention time of the wastewater within these structures, solids will almost always accumulate over time. These solids may include large objects, sand, grit, and some lint that is removed from the items during the water washing. Laundries will periodically will clean this sludge from the catch basin and dispose of it, usually in a nonhazardous landfill.

Many industrial laundries (77 percent of the 190 in-scope facilities) also screen their wastewater prior to discharge. Lint is collected from these screens regularly and is disposed, usually in a nonhazardous landfill.

Some facilities (29 percent of the 190 in-scope facilities) treat their wastewater with either DAF or chemical precipitation prior to discharge. These technologies coagulate and agglomerate of organic and metal pollutants to remove them from the wastewater. The agglomerate (or floc) is removed from the treatment unit and collected as sludge (the sludge collection for each of these units was described in Sections 6.5.6 and 6.5.7 of this document). This sludge comprises some lint and other particles from the wastewater, metal compounds that were precipitated from the wastewater, and agglomerated organic materials. Chemical precipitation typically uses lime as a coagulant, which contributes to the sludge amount that is removed from these units. Based on available data, EPA estimates that DAF units generate a median of 0.031 pounds of sludge per gallon of wastewater and chemical precipitation units generate a median of 0.039 pounds of sludge per gallon of wastewater (22). This sludge is not usually considered to be hazardous waste, although some municipalities require it to be disposed within an industrial waste landfill. Depending upon the facility's item mix, this sludge may contain a significant amount of organic material that makes the sludge suitable for incineration or fuel blending.

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